APPENDIX NOT INCLUDED

SITE INFORMATION PACKAGE

SAN JACINTO RIVER WASTE PITS

HARRIS COUNTY, TEXAS

EPA ID: TXN000606611

U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION 6

DALLAS, TEXAS

9807640

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF ACRONYMS AND ABBREVIATIONS

95UCL	95 percent upper confidence limit
°F	degrees Fahrenheit
Anchor	Anchor QEA, LLC
ARAR	applicable or relevant and appropriate requirement
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
BMP	best management practice
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CWA	Clean Water Act
cy	cubic yard(s)
dioxins	polychlorinated dibenzo-p-dioxins
EPA	U.S. Environmental Protection Agency
FCA	fish collection area
FS	feasibility study
furans	polychlorinated dibenzofurans
HI	hazard index
HpCDD	heptachlorodibenzo-p-dioxin
HQ	hazard quotient
HxCDF	hexachlorodibenzofuran
I-10	Interstate Highway 10
IC	institutional control
Integral	Integral Consulting Inc.
IRIS	Integrated Risk Information System
Mg/kg	milligram(s) per kilogram
MNR	monitored natural recovery
MSL	mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

ng/kg	nanogram(s) per kilogram
NOAEL	no observed adverse effects level
NPL	National Priorities List
OCDD	octachlorinated dibenzo-p-dioxin
PCB	polychlorinated biphenyl
pg/kg	picogram(s) per kilogram
pg/L	picogram(s) per liter
RAO	remedial action objective
RBA	relative bioavailability adjustment
RfD	reference dose
RI	remedial investigation
SF	slope factor
SIP	Site Information Package
Site	San Jacinto River Waste Pits
SLERA	screening level ecological risk assessment
SPME	solid-phase micro extraction
S/S	solidification and stabilization
SVOC	semivolatile organic compound
TCEQ	Texas Commission on Environmental Quality
TCRA	Time Critical Removal Action
TCDD	tetrachlorodibenzo-p-dioxin
TCDF	tetrachlorodibenzofuran
TDSHS	Texas Department of State Health Services
TEQ_{DF}	2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient
$TEQ_{P,M}$	dioxin-like PCB congeners toxicity equivalent quotient calculated using toxicity equivalency factors for mammals
TMDL	total maximum daily load
TOC	total organic carbon
TPWD	Texas Parks and Wildlife Department
TxDOT	Texas Department of Transportation
UAO	Unilateral Administrative Order
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Society
VOC	volatile organic compound

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PART 1: THE DECLARATION

1.1 SITE NAME AND LOCATION

The San Jacinto River Waste Pits Site is located in Harris County, Texas. The National U.S. Environmental Protection Agency (EPA) Superfund Database Identification Number is TXN000606611. This site is a single operable unit and areas and media within the site are discussed in this Site Information Package (SIP).

1.2 STATEMENT OF BASIS AND PURPOSE

This SIP presents the Preferred Remedy for the San Jacinto River Waste Pits Site in Harris County, Texas. The Preferred Remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 U.S. Code §9601 et seq., as amended by the Superfund Amendments and Reauthorization Act of 1986; and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300, as amended. The Preferred Remedy is based on the administrative record for the site, which has been developed in accordance with Section 133(k) of CERCLA, 42 U.S. Code §9613(k).

The State of Texas, acting through the Texas Commission on Environmental Quality (TCEQ), was provided the opportunity to review and comment on the Preferred Remedy.

1.3 ASSESSMENT OF THE SITE

The preferred response action in this SIP is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

1.4 DESCRIPTION OF THE PREFERRED REMEDY

The Preferred Remedy will be a final action for the San Jacinto River Waste Pits Site. It addresses site related unacceptable human health risks associated with consumption of fish and direct contact (skin contact and incidental ingestion) with sediment and soil. It also addresses site related ecological risks to bottom-dwelling organisms (benthic invertebrates), birds, and mammals.

The Preferred Remedy includes excavation and off-site disposal of principal threat waste source materials (i.e., mobile and highly-toxic sediment and soil) from impoundments in and adjacent to the San Jacinto River. Institutional Controls (ICs) will be used to prevent disturbance of the dredge residuals below the cover layers in the remediated areas (e.g., dredging, anchoring, construction, and excavation) and alert future property owners of subsurface materials exceeding cleanup goals. Monitored natural recovery (MNR) will be used to ensure remedy protectiveness in the aquatic environment.

The Preferred Remedy includes the following major components:

- Removal of existing temporary armored cap installed under the time-critical removal action (TCRA)
- Removal of approximately 200,100 cubic yards (cy) of material exceeding the sediment cleanup goal of 200 nanograms per kilogram (ng/kg) 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) toxicity equivalent quotient (TEQ_{DF}[1]) and 2 milligrams per kilogram (mg/kg) polychlorinated biphenyls (PCBs) that is located beneath the armored cap and to the west of the armored cap north of Interstate Highway 10 (I-10)
- Placement of two layers of clean fill over the remediated area under the location of the former armored cap and to the west of the armored cap to reduce intermixing of sediments
- Excavation of approximately 50,000 cy of soil exceeding the soil cleanup goal of 240 ng/kg TEQ_{DF} to a depth of 10 feet below grade in the peninsula south of I-10
- Dewatering and stabilization of dredged and excavated materials prior to off-site disposal
- A waterway use restriction to prevent disturbance of the remediated area within the river from dredging or anchoring
- Environmental covenants to restrict use of the upland remediated areas
- Deed notices to alert future property owners of subsurface materials
- MNR of the river.

1.5 STATUTORY DETERMINATIONS

The Preferred Remedy satisfies the statutory requirements of CERCLA Section 121, 42 U.S. Code §9621. It is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate requirements (ARARs) to the remedial action, is cost effective, and utilizes permanent solutions and alternate treatment or resource recovery technologies to the maximum extent practicable.

The Preferred Remedy also satisfies the statutory preference for treatment as a principal element of the remedy by reducing the mobility of hazardous substances.

[1] TEQ_{DF} calculated using toxicity equivalent factors for mammals (Van den Berg et al. 2006, EPA 2010a).

Because this Preferred Remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will need to be conducted pursuant to 40 CFR § 300.430(f)(4)(ii) within 5 years after initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

PART 2: THE SITE INFORMATION PACKAGE SUMMARY

This Site Information Package Summary provides a description of the site-specific factors and analyses that led to the Preferred Remedy. It includes background information, the nature and extent of contamination, assessment of human health and environmental risks posed by contamination, and identification and evaluation of remedial action alternatives for the site.

2.1 SITE NAME, LOCATION AND BRIEF DESCRIPTION

The San Jacinto River Waste Pits Site is located in Harris County, Texas (Figure 1). The National EPA Superfund Database Identification Number is TXN000606611. The EPA is the lead agency and the TCEQ is the support agency. Cleanup monies will be sourced from the potentially responsible parties.

The site consists of a set of impoundments built in the mid-1960s for the disposal of solid and liquid pulp and paper mill wastes, and the surrounding areas containing sediments and soils impacted by waste materials disposed in the impoundments. The northern set of impoundments, approximately 14 acres in size, are located on the western bank of the San Jacinto River, immediately north of the I-10 bridge over the San Jacinto River (Figure 2). The southern impoundment, less than 20 acres in size, is located on a small peninsula that extends south of I-10 (Figure 2). The wastes that were deposited in the impoundments are contaminated with polychlorinated dibenzo-p-dioxins (dioxins) and polychlorinated dibenzofurans (furans). Physical changes at the site during the 1970s and 1980s, including regional subsidence of land in the area due to large scale groundwater extraction, have resulted in partial submergence of the impoundments north of I-10 and exposure of the contents of the impoundments to surface water of the San Jacinto River.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

This section provides background information on past activities that have led to the current contamination at the site, and federal and state investigations and cleanup actions conducted to date under CERCLA.

2.2.1 *Historical Activities*

In the 1960s, McGinnes Industrial Management Corporation transported liquid and solid pulp and paper mill wastes by barge from the Champion Papers Inc. paper mill in Pasadena, Texas to impoundments located north and south of I-10, adjacent to the San Jacinto River, where the waste was stabilized and disposed. Champion Papers Inc. business records indicate the paper mill produced pulp and paper using chlorine as a bleaching agent (EPA 2009). The pulp bleaching process forms dioxins and furans as a by-product. The northern impoundments were used for waste disposal from September 1965 to May 1966 (EPA 2009). Details regarding the southern impoundment are less well known; however the impoundment was likely constructed sometime between 1962 and 1964 based on evidence of berms visible in historical photos (Integral Consulting Inc. [Integral] and Anchor QEA, LLC [Anchor] 2013a). Historical activities for each area are discussed below, information is summarized from Integral and Anchor (2013a), unless otherwise noted.

Northern Impoundments

In 1965, impoundments north of I-10 were constructed by forming berms within the estuarine marsh, to the west of the main channel of the San Jacinto River. The impoundments were divided by a central berm running lengthwise (north to south) through the middle, and were connected with a drain line to allow flow of excess water (including rain water) from the impoundment located to the west of the central berm into the impoundment located to the east of the central berm (Figure 3). The excess water collected in the impoundment located to the east of the central berm was supposed to be pumped back into barges and taken off-site (Anchor and Integral 2010).

On 27 December 1965, the Harris County Health Department observed pumping of liquid waste out of one of the ponds directly into the San Jacinto River (EPA 2009). The Harris County Health Department instructed McGinnes Industrial Management Corporation and Champion Papers, Inc. by letter to stop discharging to the San Jacinto River and demanded that the levees surrounding the impoundments be repaired (EPA 2009). An internal memo, dated 30 December 1965, from Champion Papers Inc. confirmed water seepage along the levees and that portions of the levees required reinforcement (EPA 2009).

In May 1966, the Texas Department of Health investigated Champion Papers Inc. waste disposal practices. Seepage was noted on the western waste pond and deteriorating levees on the eastern waste pond. The Texas Department of Health also noted that storm events had the potential to cover the disposal area with water and wash out the levees.

On 29 July 1966, the Texas Water Pollution Control Board granted McGinnes Industrial Management Corporation permission to release a combination of stabilized waste water and rain water from waste ponds into the San Jacinto River. It was also noted that the waste ponds would no longer be used for the storage of waste material (EPA 2009).

Physical changes at the site in the 1970s and 1980s, including regional subsidence of land in the area due to large scale groundwater extraction and sand mining within the river and marsh to the west of the northern impoundments, have resulted in partial submergence of the impoundments north of I-10 and exposure of the contents of the impoundments to surface waters.

During the mid- to late 1990s, third-party dredging likely occurred in the vicinity of the perimeter berm at the northwest corner of the northern impoundments.

Southern Peninsula

The peninsula south of I-10 has a complicated history that includes evidence of disposal of paper mill waste, disposal of anthropogenic waste, and subsequent industrial activities. An impoundment located on the southern peninsula and used for disposal of paper mill waste was likely constructed sometime between 1962 and 1964, based on evidence of berms visible in historical photos. The oldest aerial photo that contains evidence of the construction of berms is from 1964. The berms that seem to define an impoundment, appear to have been formed in the same manner as the impoundments north of I-10, with sidecast from trenching providing the berms of the impoundment that ultimately contained the waste. The extent of the area potentially affected by waste disposal in the southern impoundment is uncertain, but is most likely within the area enclosed by the berms.

The impoundment on the southern peninsula was also used for dumping of various anthropogenic wastes (e.g., wood, plastic sheeting, paint chips, ceramic shards) since at least the early 1970s. Aerial photographs and anecdotal information indicate that the impoundment berms were still visible in 1972, when the current landowner's family purchased the property on which they were located. Soon after 1972, the impoundment berms were graded down.

The entire peninsula south of I-10 was subject to continuous and significant modification from the early 1970s through the 1980s. From 1985 to 1998, Southwest Shipyards leased a portion of the western shoreline of the southern peninsula, immediately to the south of the present-day location of Glendale Boat Works operations on property owned by New Lost River, LLC. This area includes the shoreline area that appears to be flooded in the 1973 aerial photograph and that was filled in by 1984. Southwest Shipyards conducted sandblasting and painting of barges in this area, and spent blast sand was stockpiled along an unknown portion of the shoreline. Aerial photographs provide evidence of deposition and transport of large volumes of material, significant changes in the form of the landscape, and continuous physical change from at least 1972 to the present.

2.2.2 *Pre-CERCLA Investigations*

Between 1993 and 1995, the City of Houston conducted a toxicity study of the Houston Ship Channel that included the San Jacinto River in accordance with the Consent Decree between EPA and the City of Houston. Sediment, fish, and crab samples were collected in August 1993 and May 1994. Sediment, fish, and crab samples collected near the site indicated elevated dioxin and furan levels (ENSR Consulting and Engineering and Espey, Huston and Associates 1995).

Between 2002 and 2004, the TCEQ conducted a study of total maximum daily loads (TMDL) for dioxins and furans in the Houston Ship Channel (University of Houston, Parsons Engineering, and PBS&J 2004a). Sediment, fish, and crab samples were collected in the Summer of 2002, Fall 2002, Spring 2003, and Spring 2004. The data indicated the continued presence of dioxin and furan contamination in the San Jacinto

River surrounding the site. Results indicated standards were exceeded in 97 percent of fish samples and 95 percent of crab samples (Anchor and Integral 2010). A subset of data collected is presented in the table following the next paragraph.

In April 2005, the Texas Parks and Wildlife Department (TPWD) sent a letter notifying TCEQ of the existence of former waste pits in a sandbar in the San Jacinto River north of I-10. The letter included: 1) discussion of anecdotal evidence, that indicated the pits were likely used from the mid-1960's to mid-1970's for disposal of paper mill waste, 2) data collected during the Houston Ship Channel Toxicity Study (ENSR Consulting and Engineering and Espey, Huston and Associates 1995) and TMDL study (University of Houston, Parsons Engineering, and PBS&J 2004a), presented below, 3) documentation of U.S. Army Corps of Engineers (USACE) dredge and fill permits in the area, and 4) requested that TCEQ further investigate the site (TPWD 2005).

Water, Sediment, and Tissue Data Summarized in Texas Parks and Wildlife 2005 Letter

Date	Media	Analyte	Result	Site Specific Target	Units
Houston Ship Channel Toxicity Study[1]					
August 1993	Sediment	TEQ_{DF}	46.1	--	ng/kg
May 1994	Sediment	TEQ_{DF}	27.2	--	ng/kg
1995	Blue Catfish	TEQ_{DF}	2.31	--	ng/kg
1995	Crabs	TEQ_{DF}	2.47	--	ng/kg
Texas Commission on Environmental Quality Total Maximum Daily Load Study for Station 11193[2]					
Summer 2002	Water[3]	TEQ_{DF}	0.4661	0.0933	pg/L
Summer 2002	Sediment	TEQ_{DF}	103.23	--	ng/kg dry wt
Summer 2002	Sediment	TEQ_{DF}	19,117.13	470	ng/kg organic carbon normalized
Summer 2002	Fish Tissue	TEQ_{DF}	13.117	0.47	ng/kg wet wt
Summer 2002	Crab Tissue	TEQ_{DF}	5.519	0.47	ng/kg wet wt
Fall 2002	Water[3]	TEQ_{DF}	2.6720	0.0933	pg/L
Fall 2002	Sediment	TEQ_{DF}	63.89	--	ng/kg dry wt
Fall 2002	Sediment	TEQ_{DF}	10,473.61	470	ng/kg organic carbon normalized
Fall 2002	Fish Tissue	TEQ_{DF}	4.845	0.47	ng/kg wet wt
Fall 2002	Crab Tissue	TEQ_{DF}	1.361	0.47	ng/kg wet wt
Spring 2003	Water[3]	TEQ_{DF}	3.0948	0.0933	pg/L
Spring 2003	Sediment	TEQ_{DF}	138.96	--	ng/kg dry wt
Spring 2003	Sediment	TEQ_{DF}	16,543.27	470	ng/kg organic carbon normalized
Spring 2003	Fish Tissue	TEQ_{DF}	5.734	0.47	ng/kg wet wt
Spring 2003	Crab Tissue	TEQ_{DF}	4.490	0.47	ng/kg wet wt
Spring 2004	Water[3]	TEQ_{DF}[4]	1.2524	0.0933	pg/L
Spring 2004	Sediment	TEQ_{DF}	91.27	--	ng/kg dry wt
Spring 2004	Sediment	TEQ_{DF}	19,013.54	470	ng/kg organic carbon normalized
Spring 2004	Fish Tissue	TEQ_{DF}	5.08	0.47	ng/kg wet wt
Spring 2004	Crab Tissue	TEQ_{DF}	3.35	0.47	ng/kg wet wt
Summer 2004	Shallow Water[3]	TEQ_{DF}	1.4484	0.0933	pg/L
Summer 2004	Deep Water[3]	TEQ_{DF}	2.3318	0.0933	pg/L
Summer 2004	Sediment	TEQ_{DF}[4]	55.13	--	ng/kg dry wt
Summer 2004	Sediment	TEQ_{DF}[5]	15.96	--	ng/kg dry wt
Summer 2004	Sediment	TEQ_{DF}[6]	11.66	--	ng/kg dry wt
Summer 2004	Sediment	TEQ_{DF}[4]	4,825.95	470	ng/kg organic carbon normalized
Summer 2004	Sediment	TEQ_{DF}[5]	3,711.40	470	ng/kg organic carbon normalized
Summer 2004	Sediment	TEQ_{DF}[6]	2,082.23	470	ng/kg organic carbon normalized

Note:
[1] ENSR Consulting and Engineering and Espey, Huston and Associates. 1995. *Houston Ship Channel Toxicity Study Project Report.* Document Number 1591R001.01. June.
[2] Data from five University of Houston, Parsons Engineering and PBS&J reports as referenced below:

———. 2003. *Total Maximum Daily Loads for Dioxins in the Houston Ship Channel.* Prepared for the Texas Commission on Environmental Quality, Total Maximum Daily Load Program. October.

———. 2004a. *Total Maximum Daily Loads for Dioxins in the Houston Ship Channel.* Quarterly Report No. 1. Prepared for the Texas Commission on Environmental Quality, Total Maximum Daily Load Program. January.

———. 2004b. *Total Maximum Daily Loads for Dioxins in the Houston Ship Channel.* Quarterly Report No. 2. Prepared for the Texas Commission on Environmental Quality, Total Maximum Daily Load Program. April.

———. 2004c. *Total Maximum Daily Loads for Dioxins in the Houston Ship Channel.* Quarterly Report No. 4. Prepared for the Texas Commission on Environmental Quality, Total Maximum Daily Load Program. November.

———. 2005. *Total Maximum Daily Loads for Dioxins in the Houston Ship Channel.* Quarterly Report No. 5. Prepared for the Texas Commission on Environmental Quality, Total Maximum Daily Load Program. January.

[3] Total concentration in water obtained by summing dissolved and suspended concentrations.
[4] Average of two values
[5] At Station 18389 upstream
[6] At Station 18390 downstream
-- - not reported
ng/kg – nanograms per kilogram
pg/L – picograms per liter
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient
wt - weight

A preliminary assessment and screening site inspection was conducted between 2005 and 2006 to determine if the site was eligible for proposal to the National Priorities List (NPL) (TCEQ 2005). Site reconnaissance identified the surface water pathway as the primary pathway of concern. Seventeen sediment samples were collected from the

San Jacinto River to evaluate background, potential source areas, and possible releases. Samples were analyzed for semivolatile organic compounds (SVOCs), pesticides, PCBs, dioxins and furans, and metals. Sediment sample results indicated elevated concentrations of dioxin congeners. The former surface impoundments were identified as the source of hazardous substances at the site (TCEQ 2006).

The Hazard Ranking System is the principal mechanism the EPA uses to place sites on the NPL. The Hazard Ranking System Documentation Record for the site was published by TCEQ in 2007. The site score was 50 because of components of the surface water overland/flood migration pathway (TCEQ 2007). Any site scoring 28.5 or greater is eligible for the NPL (EPA 1992).

2.2.3 *National Priorities List*

The site was proposed for listing on the NPL List on 19 September 2007, and was placed on the list effective 19 March 2008 (73 FR 14723).

2.2.4 *Unilateral Administrative Order for Remedial Investigation/Feasibility Study*

On 17 July 2009, the EPA sent Special Notice Letters to International Paper Company and McGinnes Industrial Management Corporation offering them an opportunity to negotiate and enter into an Administrative Order on Consent covering the performance of a Remedial Investigation (RI)/Feasibility Study (FS) for the site. EPA did not receive a Good Faith Offer in which to begin negotiations for a RI/FS for the site (EPA 2009).

On 20 November 2009, the EPA issued Unilateral Administrative Order (UAO) CERCLA Docket No. 06-03-10 to International Paper Company and McGinnes Industrial Management Corporation. International Paper Company is the successor to Champion Papers Inc. Champion Papers Inc. had arranged for the disposal or treatment of materials containing hazardous substances that were disposed of at the site (EPA 2009). McGinnes Industrial Maintenance Corporation operated the waste disposal facility at the time of disposal of hazardous substances at the site (EPA 2009). The UAO directed International Paper Company and McGinnes Industrial Management Corporation to conduct a RI/FS in accordance with provisions of the order, CERCLA, the NCP, and EPA guidance. The UAO includes a basic history of the impoundments located north of I-10. EPA also required the investigation of an impoundment located south of I-10 because historical documents indicate that waste disposal activities occurred in this area (Integral and Anchor 2013a).

Between 2010 and 2013, site-specific data were collected for the RI. The RI included the collection of sediment, tissue, soil, and groundwater samples. Physical data were collected and solid-phase micro extraction (SPME) porewater samplers were also evaluated as part of the RI.

Three hundred and fifty seven sediment samples were collected during the RI to evaluate the nature and extent of contamination, exposure, and determine an appropriate background tissue location. Sediment samples were collected from 0 to 6 inches, 6 to 12 inches, or in 1-foot intervals at depths ranging from 3 to 10 feet.

Sediment samples were analyzed for a combination of the following analyses: dioxins and furans, PCBs, metals, SVOCs, volatile organic compounds (VOC), grain size, and total organic carbon (TOC).

One hundred eighty three tissue samples were collected during the RI to provide sufficient data to complete the baseline human health and ecological risk assessments and to evaluate biota-sediment relationships. Skin off fillets were collected from 50 hardhead catfish. The remainders of 18 hardhead catfish fillets from the fillet samples were also collected for analysis. Eighteen whole-body Gulf killifish were collected. The edible tissue from 35 common rangia clam was collected. The edible tissue from 50 blue crabs was collected. The remainders of crab after edible tissue was removed was analyzed for 12 blue crab samples. These tissue and remainder samples were analyzed for dioxins and furans and a subset were analyzed for PCBs, metals, and SVOCs.

Three hundred ninety two soil samples were collected during the RI to evaluate the nature and extent of contamination, exposure, fate and transport, and document right-of-way conditions. Soil samples were analyzed for a combination of the following analyses: dioxins and furans, PCBs, metals, SVOCs, VOCs, grain size, and TOC. An even smaller subset of samples were analyzed for pesticides, PCBs as Aroclors, and asbestos.

Thirteen monitoring wells were installed during the RI. Three well pairs located on the berms of the northern impoundments, one well within the wastes of the western cell of the northern impoundment, and three monitoring wells in the area of investigation south of I-10 as documented in the RI report (Integral and Anchor 2013a). During subsequent field activities, two shallow wells and one deep well were installed in the area of investigation south of I-10 as documented in the RI Addendum 1 (Anchor and Integral 2013). Groundwater samples were collected from the monitoring wells and analyzed for dioxins and furans, PCBs, metals, SVOCs, and total suspended solids to evaluate the nature and extent of contamination and the fate and transport of contaminants.

Physical data collected during the RI included: a bathymetric survey, current velocity (included surface water elevation and salinity), material, geotechnical, and riverbed properties, sediment loaded, erosion rates of cohesive sediment, and net sedimentation rates (through profiling vertical distribution of radioisotopes) (Integral and Anchor 2013a).

In addition to requirements of the *Operations, Monitoring, and Maintenance Plan* (Anchor 2011), discussed in Section 2.2.5, a porewater assessment was performed to evaluate the effectiveness of the TCRA armored cap. Porewater SPME samplers were deployed and retrieved. The sampling objective was to collect data on dioxins and furans in porewater in order to determine if vertical gradients in concentrations of dioxins and furans in cap porewater exists and to determine if porewater concentrations in the cap differ from concentrations in surface water above the cap.

The results of the RI are documented in other sections of this SIP, where relevant.

2.2.5 *Administrative Settlement Agreement and Order on Consent for Removal Action*

On 2 April 2010, EPA submitted an Action Memorandum to the EPA Region 6 Superfund Division Director requesting approval of a TCRA to stabilize the site to temporarily abate the release of contaminants including dioxins and furans into the San Jacinto River from the northern impoundments until the site was fully characterized and a remedy selected.

On 11 May 2010, EPA filed the Administrative Settlement Agreement and Order on Consent for Removal Action, CERCLA Docket No. 06-12-10 (EPA 2010b). The Administrative Settlement Agreement and Order on Consent was entered into voluntarily by the EPA, International Paper Company and McGinnes Industrial Management Corporation. The Administrative Settlement Agreement and Order on Consent for Removal Action provided for the performance of a removal action and the reimbursement of certain response costs.

The EPA Action Memorandum required that the TCRA stabilize the impoundments to withstand forces sustained by the river, including a cover design that considered storm events with a return period of 100 years (Figure 3). The EPA Action Memorandum also required that the TCRA prevent direct human and benthic organism contact with waste materials. The TCRA actions were required to be consistent with the long-term remediation strategies that may be developed for the site.

Elements of the selected TCRA included construction of a perimeter fence on the uplands to prevent unauthorized access, placement of warning signs around the perimeter of the impoundments and on the perimeter fence, design and implementation of an operations, monitoring, and maintenance plan, and installation of the following items:

- A stabilizing geotextile underlayment over the eastern cell
- An impervious geomembrane underlayment in the western cell
- A granular cover over the northwestern area of the western cell
- A granular cover above the geotextile and geomembrane in the western cell
- A granular cover above the geotextile in the eastern cell.

Additionally, the western cell received treatment through stabilization and solidification of approximately 6,000 cy of material in the upper 3 feet of material.

From December 2010 through July 2011, TCRA construction activities were completed at the site. On 1 August 2011, EPA conducted a final site walk through accompanied by International Paper Company, McGinnes Industrial Management Corporation, Anchor, and USA Environment, LP. The *Revised Final Removal Action Completion Report*, which documents the TCRA construction activities, was completed May 2012 (EPA 2012a).

The *Operations, Monitoring, and Maintenance Plan, Time-Critical Removal Action, San Jacinto River Waste Pits Superfund Site* identifies continuing obligations, including monitoring and maintenance, with respect to the TCRA (Anchor 2011). Inspections of fencing, signage, and the protective armored cap are required quarterly for the first 2 years following completion of the TCRA (January 2012 through December 2013), semiannually for years three to five (April 2014 through October 2016), and annually starting at year six (July 2017 and beyond). Following discovery in December 2015 and repair of the underwater armored cap deficiency area on the northwest part of the cap, the EPA directed the potentially responsible parties, on 16 February 2016, to resume quarterly cap inspections until further notice. Inspections of the armored cap are also required following the first 25-year flow event and after each 100-year flow event. TCRA inspection events include:

- Visual inspection of the security fence and signage surrounding the site
- Visual inspection of the armored cap located above the water surface
- Visual observation that waste materials are not actively eroded into the river
- Collection of topographic survey data for the portions of the armored cap that are located above the water surface or at a water depth too shallow to access by boat
- Collection of bathymetric survey data for the portions of the armored cap that are below the water surface and accessible by boat
- Manual probing of armored cap thickness at areas identified by the topographic or bathymetry surveys as more than 6 inches lower in elevation than during the prior survey.

If the visual inspection identifies a breach in the security fence or damaged or missing signs, repairs or replacement will be made as soon as practicable, but not to exceed two weeks following the inspection. Repair activities to the armored cap are required if (1) the thickness of the armored cap is less than 6 inches than the thickness specified by the TCRA design over a contiguous area greater than 30 feet by 30 feet in size, (2) the armored cap has any area of complete absence, or (3) visual observation indicates that waste materials are being actively eroded into the river. Inspection and repair reports, as needed, are submitted to EPA.

Since its completion in July 2011, the armored cap has generally isolated and contained impacted material. The following events, summarized in the FS (EPA 2016), have been documented since the time of armored cap installation:

- In July 2012, an area along the western berm slope was noted to have areas where cap armor materials had moved down the slope, uncovering a small area of the geotextile layer (approximately 200 square feet, or 0.03 percent of the armored cap footprint). There was no exposure of underlying materials or release of hazardous substances associated with this temporary condition. Maintenance measures were completed that involved grading specific locations to an overall flatter condition by placing additional armor rock over the cap surface in those locations.

- In January 2013, five areas in the eastern cell of the cap with less than the required armor cover thickness and/or exposed geotextile were identified. In one of those areas there is a need for placement of geotextile fabric in addition to armor stone. The cause of these areas of deficient cap cover is unknown. These areas were repaired in January 2013 with the addition of additional stone and geotextile.

- In response to USACE recommendations following their post-construction evaluation (USACE 2013) of the armored cap, additional cap enhancement work was completed in January 2014. In order to address the factor of safety, slope of the face of the berm, and uniformity of cap material, additional stone was placed on the armored cap.

- On 9 and 10 December 2015, EPA performed an underwater inspection that identified an area of deficient thickness and/or missing armor cover resulting in exposure of the underlying paper mill waste material to the San Jacinto River. The deficient area, approximately 22 feet by 25 feet, was located on the northwestern section of the armored cap where no geotextile was installed. Armored rock cover was still present, but coverage was not complete and was not of adequate thickness. The cause of the deficient area is unknown. Sediment sampling completed in December 2015 identified dioxins and furans in the exposed sediment as high as 43,700 ng/kg TEQ_{DF}. Maintenance activities to place geotextile and additional rock cover over and extending beyond the deficient area were completed on 4 January 2016.

- On 24 February 2016, during an extremely low tide, a visual inspection of the cap was performed. A large majority of the eastern cell was exposed during this abnormally low tide event. Five small areas (approximately 1 foot by 3 feet at the largest areas) of exposed geotextile with no rock cover were observed in the central part of the eastern cell where the cap should have had a 1-foot thickness minimum. The cause of these deficient rock areas is unknown, although some of the areas may have been geotextile overlap portions associated with the cap construction. During March 2016 probing of the entire eastern cell of the cap to check thickness was completed and identified additional areas of deficient armor cover thickness and/or exposed geotextile. Rock was added to all of these areas in the eastern cell in March 2016 to achieve a minimum thickness of 1 foot.

2.3 COMMUNITY PARTICIPATION

This section of the SIP describes the EPA's community involvement and participation activities. EPA has been actively engaged with stakeholders and has encouraged community participation during EPA's remedial and removal activities. These community participation activities during the remedy selection process meet the public participation requirements in CERCLA 300.430(f)(3) and the NCP.

EPA in cooperation with Elected Officials, State, County, and Local Agencies has been providing a steady program of community outreach and public participation for the site since the site was listed to the NPL in 2008. EPA and the State first met with area agencies such as the Houston-Galveston Area Council to update plans for site cleanup under the Superfund Program.

EPA and its partner agencies such as Harris County has provided a robust and comprehensive program of community involvement and public participation for the site. Starting with a World Café' initiative Community Meeting in 2010 to brief the public on the new NPL site, share information on the Superfund process, the next steps, and how the community could get involved in this very technical remediation. As a result of intensive community interest, the site was deemed a Community Engagement Initiative site by EPA Headquarters which led to additional outreach planning such as informational meetings and mail outs to a large site mailing list.

Starting in late 2010, the EPA initiated a Community Advisory Group for the site known as the Community Awareness Committee which began a series of quarterly meetings at the Harris County Attorney's office. In 2012, the EPA provided a Technical Assistance Grant to the Galveston Bay Foundation to hire a technical advisor to provide assistance. And, a number of local web sites are being utilized to keep area citizens updated on site events.

EPA has since provided a number of Community Meetings, Open Houses, Elected Officials briefings, media interviews, Public Notices, and fact sheets to inform the public and keep residents updated on all site developments that affect cleanup actions. Site fact sheets are available on EPA's website at the uniform resource identifier below:

https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0606611.

2.3.1 *Information Repositories*

The Administrative Record file is available for review at:

Highlands Public Library
Stratford Branch Library
509 Stratford Street
Highlands, Texas 77562
(281) 426-3521

U.S. Environmental Protection Agency, Region 6
1445 Ross Avenue, Suite 700
Dallas, Texas 75202
(800) 533-3508

Texas Commission on Environmental Quality
Building E, Records Management, First Floor
12100 Park 35 Circle
Austin, Texas 78753
(512) 239-2900 and (800) 633-9363

2.4 SCOPE AND ROLE OF RESPONSE ACTION

The NCP, 40 CFR Section 300.5, defines an operable unit as a discrete action that comprises an incremental step toward comprehensively addressing a site's contamination problems. The cleanup of a site may be divided into one or more operable units, depending on the complexity of the problems associated with the site. The EPA has chosen to address the site as a whole without division into operable units. The Preferred Remedy addresses the contaminated environmental media at the site with the primary objectives of preventing human exposure to contaminants, preventing or minimizing further migration of contaminants. The remedial action objectives (RAOs) are described in detail in Section 2.8.

2.5 SITE CHARACTERISTICS

This section presents a brief, comprehensive overview of the site. This section has been divided into three subsections that include physical characteristics, conceptual site model, and the nature and extent of contamination.

2.5.1 *Physical Characteristics*

This subsection provides a summary of site surface features, climate, surface water hydrology, geology, ecology, and habitats. Detailed information on these topics can be found in the *Remedial Investigation Report, San Jacinto River Waste Pits Superfund Site* (Integral and Anchor 2013a).

Surface Features

The site is located in the estuarine portion of the lower San Jacinto River where the river begins to transition from a fluvial system to a deltaic plain. The northern impoundments cover an area approximately 15.7 acres in size. Pre-TCRA ground surface elevations ranged from 0 feet above mean sea level (MSL) at the shoreline, to less than 10 feet above MSL. South of I-10, ground surface elevations range from 0 feet above MSL at the shoreline to nearly 13 feet above MSL. Both areas are generally flat with very little noticeable topographic relief. Relief south of I-10 is likely result of building foundations and leftover cut material from grading.

Climate

The climate along the Gulf Coast of Texas and the area surrounding Houston is humid subtropical. The average annual precipitation is 54 inches. The warmest month is July, with an average temperature of 85 degrees Fahrenheit (°F), and the coldest month is

January, with an average temperature of 54°F. During the spring season, large thunderstorms are common and are capable of producing tornados. The transition to the summer months is characterized by mild temperatures, but relative humidity of up to 90 percent results in a higher heat index.

The monthly average precipitation varies from approximately 2.5 inches in February to over 7 inches in June. It is not uncommon to have precipitation events that exceed 2 inches per day, and rain events bringing 10 inches of precipitation or higher in a day occur on a decadal scale. These types of precipitation events produce wide variations in the volume of discharge into and out of the San Jacinto River and may significantly affect variations in flow velocities, sediment transport, and suspended sediment loads.

Tropical weather systems can have tremendous impacts on regional precipitation and hydrology along the Gulf Coast. Hurricane season runs from June 1 to November 30. The north Texas Gulf Coast has recently documented major storms (Category 3 to 5) in 2005 and 2008 as further discussed in the Surface Water Hydrology subsection below.

Surface Water Hydrology

Water depths near the site range from relatively shallow in intertidal areas (3 feet or less) to relatively deep in the main channel of the river (about 30 feet). The river in the vicinity of the site is affected by diurnal tides, with a typical tidal range of about 2 feet. Tidal range varies over a 14-day cycle, with neap and spring tide conditions corresponding to minimum and maximum tidal ranges, respectively. Tropical storms and wind storms from the north can have significant effects on water levels. Hurricane storm surges usually cause increases in water depth of 4 to 6 feet. Storms with strong winds from the north can cause water to be transported out of the Galveston Bay system which can result in water levels that are much lower than low tide elevations.

Flow rates and freshwater inputs into the San Jacinto River in the vicinity of the site are partially controlled by the Lake Houston dam, which is located about 16 river miles upstream of the northern impoundments. The average flow in the river is 2,200 cubic feet per second (cfs). Floods in the river occur primarily during tropical storms (e.g., hurricanes) or intense thunder storms, as further discussed in the subsequent section. Extreme flood events have flow rates of 200,000 cfs or greater. Floods can cause water surface elevations to increase by 10 to 20 feet or more (relative to average flow conditions) and force the river out of its main channel (Figure 4). During low-flow conditions when current velocities were dominated by tidal effects, maximum velocities were measured to be about 1 foot per second, with typical velocities of 0.5 feet per second or less during most of the tidal cycle (Integral and Anchor 2013a).

Salinity in the vicinity of the site ranges between 10 and 20 parts per thousand during low to moderate flow conditions in the river. During floods, salinity values will approach freshwater conditions.

Tropical Storms and Hurricanes

Tropical weather systems can have tremendous impacts on regional precipitation and hydrology along the Gulf Coast. Hurricane season runs from 1 June 1 to 30 November. Between 1851 and 2004, 25 hurricanes have made landfall along the north Texas Gulf Coast, seven of which were major (Category 3 to 5) storms. Tropical Storm Allison, which hit the Texas Gulf Coast from 5 to 9 June 2001, resulted in 5-day and 24-hour rainfall totals of 20 and 13 inches, respectively, in the Houston area, resulting in significant flooding. More recently, Hurricane Rita made landfall on 23 September 2005, between Sabine Pass, Texas, and Johnsons Bayou, Louisiana, as a Category 3 storm with winds at 115 miles per hour and it continued on through parts of southeast Texas. The storm surge caused extensive damage along the Louisiana and extreme southeastern Texas coasts. On 13 September 2008, the eye of Hurricane Ike made landfall at the east end of Galveston Island and travelled north up Galveston Bay, along the east side of Houston. Ike made its landfall as a strong Category 2 hurricane, with Category 5-equivalent storm surge, and hurricane-force winds that extended 120 miles from the storm's center. Storms with strong winds from the north can cause water to be transported out of the Galveston Bay system, which can result in water levels that are much lower than low tide elevations.

Between 14 and 21 October 1994, heavy rainfall occurred in a 38-county area of southeast Texas. The San Jacinto River Basin received 15 to 20 inches of rain during this week-long period. One of the largest measurements of stream flow ever obtained in Texas, 356,000 cfs, was made on the San Jacinto River near Sheldon on 19 October 1994 at a stage of 27 feet. During the measurement, velocities of water that exceeded 15 feet per second (about 10 miles per hour) were observed (U.S. Geological Society [USGS] 1995). Another storm occurring in 1940 had a river stage height of 31.50 feet at the same Sheldon location. The 100-year flood, which is defined as the peak stream flow having a 1 percent chance of being equaled or exceeded in any given year, was exceeded at 18 of 43 stations monitoring the area. For those stations where the 100-year-flood was exceeded, the flood was from 1.1 to 2.9 times the 100-year-flood (National Transportation Safety Board 1996).

The 1994 flooding caused major soil erosion and created water channels outside of the San Jacinto River bed. This flooding caused eight pipelines to rupture and 29 others were undermined at river crossings and in new channels created in the flood plain outside of the San Jacinto River boundaries. The largest new channel was cut through the Banana Bend oxbow just west of the Rio Villa Park subdivision, about 2 ½ miles northwest of the site. This new channel was approximately 510-feet wide and 15-feet deep. A second major channel cut through Banana Bend just north of the channel through the oxbow. Both of these new channels were cut through areas where sand mining had been done before as is the case in the vicinity of the site. Sonar tests in a 130-foot section south of the I-10 Bridge located adjacent to the site found about 10 to 12-feet of erosion from the bottom of the river bed. The flooding forced over 14,000 people to evacuate their homes (National Transportation Safety Board 1996). The Houston Chronicle in early November listed 22 flood-related deaths and 15,775 homes damaged, including 3,069 destroyed and 6,560 requiring major repairs (USGS 1995).

Regional Geology and Hydrogeology

Sediments of the Texas Gulf Coast are generally Cenozoic fluvial-deltaic to shallow-marine deposits of a coastal plain environment (USGS 2002). Sea-level transgression-regression cycles and natural basin subsidence have produced beds of clay, silt, sand, and gravel that gently dip southeast towards the Gulf of Mexico. This complex depositional process created both a continental assemblage of sediments that now makes up the aquifers within the area and a marine sequence of sediments that contains clay layers and confining units. This process resulted in a regional aquifer system with a high degree of heterogeneity in both lateral and vertical extent (USGS 2002) commonly referred to as the Gulf Coast Aquifer System (Texas Natural Resource Conservation Commission 1999).

The Gulf Coast Aquifer System is located along the coast of the Gulf of Mexico and has been divided into four units: the Chicot, Evangeline, and Jasper aquifers, and the Burkeville confining unit. The site is above the Evangeline (deeper) and Chicot (shallower) aquifers. Groundwater elevation maps for the Evangeline and Chicot aquifers show that regional groundwater flow is directed approximately southeast towards the Gulf of Mexico (USGS 2002). On a localized net flow basis, shallow groundwater may discharge to the San Jacinto River, providing a portion of base flow. Under high tide and river flow conditions, a temporary gradient reversal may cause the San Jacinto River to temporarily recharge the shallow alluvium adjacent to the river.

The Chicot Aquifer is used as a drinking water source within the greater Houston area, but water used from this source is pumped from wells screened far below the Beaumont Formation, a confining clay. Although there are some privately owned upper Chicot Aquifer wells near the site, the infiltration of surface waters or shallow groundwater would likely be prevented by the thick sequence of the clay and silt deposits of the Beaumont Formation, effectively isolating the lower portion of the Chicot Aquifer from shallower groundwater and surface water in the vicinity (USGS 2002).

Local Geology and Hydrogeology

At the site, the surface and underlying local soils include Holocene alluvial deposits and the Beaumont Formation, which is the youngest and uppermost of the series of coast-parallel Pleistocene deposits that make up the Gulf Coast Aquifer System. The soils of the Beaumont Formation are dominated by clays and silts that thicken seaward and that were deposited in a fluvial-deltaic environment (Van Siclen 1991). The Beaumont formation and overlying recent alluvial soils make up the uppermost units of the Chicot Aquifer (USGS 2002).

The local water table (i.e., shallow groundwater) is found near land surface in the shallow alluvium sediments, generally at the approximate elevation of the San Jacinto River water surface. Groundwater movement in the shallow alluvium in the area is dominated by surface water and groundwater interactions with the river, which surrounds the former impoundments north of I-10 and the area to the south. In regions such as the site (i.e., shallow water table, relatively flat topography), groundwater discharges to surface water bodies (Fetter 1994; Freeze and Cherry 1979). This reach of the San Jacinto River watershed is characterized by extremely flat groundwater gradients indicating that the area surrounding the site is an area of minimal recharge to the aquifers. The Beaumont Formation is a confining unit that isolates shallow groundwater in the Holocene alluvium and in the San Jacinto River sediments from the underlying formations of the Chicot Aquifer.

Habitats Overview

The site is located in a low-gradient, tidal estuary near the confluence of the San Jacinto River and the Houston Ship Channel. Upland, riparian, and aquatic habitats are present.

Upland natural habitat adjacent to the San Jacinto River at and near the site is generally low-lying, with little topographic variation, and consists primarily of clay and sand that supports forest communities of loblolly pine-sweetgum, loblolly pine-shortleaf pine, water oak-elm, pecan-elm, and willow oak-blackgum (Texas State Historical Association 2009). Upland natural habitat occurs along narrow sections of land on either side of the river, as well as on several small islands, to the north and south of I-10 and east of the northern impoundments. Most of these islands are vegetated with a mixture of shrubs and trees, with fringing shallow waters.

Habitats on the northern portion of the site include shallow and deep estuarine waters, and shoreline areas occupied by estuarine riparian vegetation. The in-water portion of the site is unvegetated, with a deep (20- to 30-foot) central channel and shallow (3 feet or less) sides (National Oceanic and Atmospheric Administration 1995; Clark et al. 1999). Except in the northern impoundments, sediments have a high sand content and are characterized by low organic matter content (0.5 and 2 percent TOC). By contrast, most surface sediment samples collected within the northern impoundments ranged between 1 and 5 percent TOC, with the fraction consisting of sand ranging from 4 to 98 percent, and an average of about 50 percent sands.

A sandy intertidal zone is present along the shoreline throughout much of the site. Minimal habitat is present in the upland sand separation area located adjacent to the northern impoundments, because demolition and closure of this former industrial area created a denuded upland with a covering of crushed cement and sand. The sandy shoreline of this area is littered with riprap, other metal debris, and piles of cement fragments. Prior to implementation of the TCRA, estuarine riparian vegetation lined the upland area that runs parallel to and north of I-10. As a result of the TCRA, that area now includes a dirt road. The western cell of the impoundments north of I-10 had been occupied by estuarine riparian vegetation to the west of the central berm until the recent implementation of the TCRA, when the vegetation was removed. The eastern cell, also completely covered as a result of the TCRA, lies within intertidal and subtidal habitats.

Throughout the broader surrounding area, there are approximately 55 additional acres of freshwater, estuarine, and marine wetlands (Figure 5). The vegetation associated with the estuarine intertidal wetland documented on the northern impoundments is no longer present as a result of the TCRA, but could return over time. Major vegetation associated with fringe wetland areas included broadleaf cattail, saltmeadow cordgrass, saltmarsh aster, and marsh elder. Wetland habitats to the south of I-10 along the eastern side of the channel include a narrow stretch of vegetation along the shoreline and the shoreline habitats of three small islands south of I-10. The vegetation on the islands mainly consists of shrubs and small trees.

2.5.2 *Conceptual Site Model*

A conceptual site model is a written description and a visual representation of the predicted relationship between a stressor and a potential receptor that describes the potential sources, release mechanisms, transport pathways, and environmental exposure media of chemicals to receptors. The conceptual site model provides a framework that facilitates application of the risk assessment process to the conditions and use of a site. Separate conceptual site models have been developed for the area north of I-10 and aquatic environment, and the area south of I-10.

North of I-10 and Aquatic Environment Conceptual Site Model

The conceptual site model for the area north of I-10 and aquatic environment is shown in Figure 6. Figure 7 identifies the potential routes of human exposure in detail and indicates whether they are considered significant or minor. For this area, hypothetical recreational and subsistence fishers, recreational visitors, and trespassers were identified as groups that may have contact with impacted media under baseline conditions.

Fishing activity within the waters surrounding the site has been observed and fishers in this area have been reported to collect whatever they catch. However, little information is available about the type and amount of fishing that occurs. Fishers may potentially be exposed to chemicals of potential concern (COPCs) via direct contact with sediments and soils, and by ingesting fish or shellfish that have been exposed to impacted media. They may also potentially be exposed to COPCs through direct contact with surface water (ingestion and dermal contact) or porewater (dermal contact), and through inhalation of COPCs as particulates or vapors in air; however, exposures via these media and routes are considered to be minor (Figure 7).

Although the lands at and near the site are largely privately owned, points of access were available to the public along and within this area under baseline conditions. Such access allowed for a variety of recreational activities other than fishing, including picnicking, walking, bird watching, wading, and boating. Shoreline use and wading at the site has been reported. Recreational visitors could potentially be exposed via the same direct contact exposure routes as fishers (i.e., incidental ingestion of and dermal contact with soils and sediments). However, these individuals are not exposed via ingestion of fish or shellfish.

Signs of trespassing have been reported in some areas at the site, particularly under the I-10 Bridge. The hypothetical trespasser is the receptor used to represent a very low level of possible exposure. Therefore, although a hypothetical trespasser could be exposed via the same pathways as the recreational visitor (i.e., direct contact pathways) and recreational fisher (i.e., ingestion of fish and shellfish), the concept of the trespasser is that of a person whose exposure would likely be intermittent and of a shorter term than the exposures being evaluated for either of those scenarios. Thus, for the area north of I-10, the estimated risks and hazards presented for the hypothetical fishers and hypothetical recreational visitors are higher than and would overstate potential risks for hypothetical trespassers. Therefore, the hypothetical trespasser scenario was not evaluated quantitatively for the area north of I-10 and aquatic environment.

South of I-10 Conceptual Site Model

The conceptual site model for the area of investigation on the peninsula south of I-10 is shown in Figure 8. Figure 9 describes the specific routes of potential exposure in detail. For this area, trespassers, commercial workers, and construction workers were identified as groups that may potentially come into contact with impacted media.

With signs of trespassing in areas along the western bank of the river at this site, it is possible that trespassers might walk around or spend time in the area of investigation on the peninsula south of I-10. Because such activities might result in direct contact with surface soil, potentially complete exposure pathways for the trespasser are incidental ingestion and dermal contact with soil. Because fencing and active management and use of industrial properties south of I-10 make this area largely inaccessible, it is anticipated that the trespasser's exposure would be infrequent. Also it is likely that trespassing activities by any given individual would be limited to a relatively short time frame (i.e., no more than a few years).

Land use on the peninsula south of I-10 is commercial/industrial. Commercial workers, who perform maintenance or other work-related outdoor activities, might have potential direct contact with surface and shallow subsurface soil. Potentially complete exposure pathways for the commercial worker are incidental ingestion and dermal contact with surface and shallow subsurface soil.

In the future, construction work could occur in the area of investigation on the peninsula south of I-10. Under this future scenario, construction workers may have direct contact with surface and subsurface soil. Potentially complete exposure pathways for the construction worker are incidental ingestion and dermal contact with surface and subsurface soils.

2.5.3 *Nature and Extent of Contamination*

The RI Report (Integral and Anchor 2013a) contains an in-depth discussion of the process involved to identify chemicals of concern (COCs) and the nature and extent of contamination (RI Report, Section 5.2 for the area north of I-10 and Section 6.2 for the area south of I-10). Results of the baseline human health risk assessment (BHHRA) indicate COCs include dioxins and furans, and PCBs (discussed in Section 2.7 of this

SIP). This section discusses the nature and extent focusing on these COCs. Information is from the RI report (Integral and Anchor 2013a), unless otherwise noted.

North of I-10 Soil TEQ_{DF}

The following discussion describes the spatial extent of dioxin and furan concentrations in soils north of I-10, including the samples collected underneath I-10 in the Texas Department of Transportation (TxDOT) Right-of-Way.

The highest averages of dioxin and furan concentrations in surface soils north of I-10 occur in Soil Investigation Area 3 (Figure 10 and Table 1), which encompasses the northern impoundments. In Soil Investigation Area 3, the maximum TEQ_{DF} concentration in surface soils (11,200 ng/kg) occurs in the southern portion of the western cell of the impoundments. Within Soil Investigation Area 3, the congener with the highest average concentration was 2,3,7,8-tetrachlorodibenzofuran (TCDF), at 6,680 ng/kg (Table 1). Average and maximum TEQ_{DF} concentrations in surface soils in Soil Investigation Areas 1 and 2 are much lower than those within the Soil Investigation Area 3 (the northern impoundments).

In subsurface soils north of I-10, the highest average concentration of dioxins and furans also occurs in Soil Investigation Area 3 (Table 2). In Soil Investigation Area 3, the highest TEQ_{DF} value in subsurface soils (16,200 ng/kg) occurs in the southern portion of the western cell (Figure 10). Consistent with surface soils within Soil Investigation Area 3, the highest average concentration for an individual congener was for 2,3,7,8-TCDF at 17,000 ng/kg (Table 2).

As with the surface soils, subsurface soil TEQ_{DF} concentrations in Soil Investigation Areas 1 and 2 are lower than those within Area 3 the northern impoundments. The maximum TEQ_{DF} concentration in subsurface soils of Soil Investigation Area 1 was 195 ng/kg and occurs in the 12- to 24-inch interval, in the northeastern corner of the upland sand separation area.

North of I-10 Soil PCBs

Outside of the 1966 impoundment perimeter and within soils north of I-10, Aroclors were detected in five samples from Soil Investigation Area 2, and were estimated in four of those. Aroclor 1254 was detected in soil from Station TxDOT002 at 130 µg/kg. Aroclors were not detected in surface and shallow subsurface soils of the upland sand separation area.

Because Aroclors were generally not detected in soils of Soil Investigation Area 1 and were rarely detected in Area 2 soils, only the dioxin-like PCB congener data (as $TEQ_{P,M}$) are used in figures, tables, and text supporting descriptions of the nature and extent of PCBs in soils. The data for dioxin-like PCB congeners provide a description over the widest possible geographical area. Aroclors 1242, 1248, 1254, and 1260 have at least one dioxin-like PCB present at greater than 0.5 percent (Frame et al. 1996); the dioxin-like congeners are therefore a reasonable surrogate for the presence of these Aroclors.

Two of the TxDOT stations in Soil Investigation Area 2 fall within the original 1966 perimeter of the impoundments north of I-10. The sample from one of these (TxDOT005) has the highest $TEQ_{P,M}$ of all 14 soil samples (2.83 ng/kg; Figure 11), but this location does not correspond with the highest station having the highest TEQ_{DF} in soils, which is at TxDOT004 (Figure 10), where the $TEQ_{P,M}$ was just 0.93 ng/kg. The second highest $TEQ_{P,M}$ concentration (2.23 ng/kg) was found at the location in Soil Investigation Area 2 furthest west of the northern impoundments, Station TxDOT007. There is no evident spatial pattern in the data for $TEQ_{P,M}$ in soils that would suggest that the impoundments north of I-10 are an important source of dioxin-like PCBs in soils. The result for Station TxDOT007 suggests that the distribution of these dioxin-like PCBs in soils north of I-10 and in the TxDOT ROW is random, and likely reflects background conditions. There are no site-specific background data for PCB congeners.

North of I-10 Groundwater TEQ_{DF}

In five of the seven monitoring wells installed north of I-10, no dioxin and furan congeners were detected. These five wells include two of the shallow wells in GWBU-A (the alluvial groundwater) and all three deep wells in GWBU-B (the unit below the Beaumont clay). One dioxin and one furan congener were detected in a well screened in GWBU-A (SJMWS02) at estimated concentrations of 3.6 picograms per liter (pg/L) (octachlorinated dibenzo-p-dioxin [OCDD]) and 1.89 pg/L (2,3,7,8-TCDF).

In the perched groundwater sample within the waste in the northern impoundments, SJMWS04, all but 4 of the 17 dioxin and furan congeners were detected or estimated at concentrations ranging from 14 pg/L to 9,100 pg/L (Table 3). This well was screened within the upper 2.5 feet of waste material in the impoundment. 2,3,7,8-TCDD was detected at a concentration of 2,700 pg/L. This is the only detection (estimated or otherwise) of 2,3,7,8-TCDD in any well north of I-10.

North of I-10 Groundwater PCBs

PCBs were analyzed as Aroclors only in the groundwater samples from locations within the 1966 perimeter of the impoundments north of I-10. Aroclors were not detected in any groundwater samples (Table 3). Matrix interferences in sample SJMWS04 likely resulted in elevated detection limits for Aroclors (Table 3).

Sediment TEQ_{DF}

The spatial distribution of TEQ_{DF} in surface and subsurface sediments is shown in Figures 12 and 13. Summary statistics for results of TEQ_{DF} as well as the individual dioxin and furan congeners on a dry-weight basis for surface and subsurface sediments are provided in Tables 4 and 5.

In the baseline dataset, the spatial extent of dioxins and furans in sediment is well-defined. Dioxin and furan concentrations in sediments, expressed as TEQ_{DF} results, are higher within the 1966 perimeter of the impoundments north of I-10 than elsewhere at the site. Within the 1966 perimeter of the impoundments north of I-10, TEQ_{DF} results in sediments are highest in the western cell. TEQ_{DF} results in sediment outside of the northern impoundments are typically 3 to 4 orders of magnitude lower than those within the impoundments, even in areas directly adjacent to the 1966 impoundment perimeter.

The highest TEQ_{DF} result (31,600 ng/kg) in surface sediment samples occurs in the uppermost 2-foot interval of the core the boring located in the north-central portion of the northern impoundments (Figure 12); cores surrounding it to the north, east, and southeast show much lower concentrations at all intervals, even within the 1966 impoundment perimeter. Cores within the western cell tend to show higher TEQ_{DF} results throughout the upper core increments. TEQ_{DF} results generally decrease from their maximum with depth within a given core indicating that the peak concentrations have been located in the vertical dimension.

TEQ_{DF} results in surface sediment samples from two locations adjacent to the upland sand separation area are above 100 ng/kg, at estimated concentrations of 121 ng/kg (Station SJNE041) and 153 ng/kg (Station SJNE032). All other TEQ_{DF} results in surface sediment outside of the 1966 impoundment perimeter are generally much lower. Grab samples with TEQ_{DF} results that are not below 100 ng/kg include four locations around the southern end of the peninsula south of I-10, and a few surface samples near the original 1966 impoundment perimeter. In the vicinity of the upland sand separation area (Station SJNE032), two deep subsurface intervals (4 to 5 feet and 7 to 8 feet below mudline) have TEQ_{DF} levels of 349 and 339 ng/kg, respectively, the highest TEQ_{DF} measured outside the 1966 northern impoundment perimeter.

Sediment PCBs

The distribution of $TEQ_{P,M}$ concentrations in surface and subsurface sediments is shown in Figures 14 and 15, respectively. Summary statistics for PCBs in surface sediments are listed in Table 6, and for subsurface sediments in Table 7. PCB congener detection frequency ranges from 0 for PCB congener169 in subsurface sediments to 87 percent for PCB congener 105 in surface sediments. In surface samples, PCB congeners 105, 118, and 156/157 have a greater than 80 percent detection frequency, while PCB congeners 81, 126, and 169 were detected in less than 20 percent of the samples.

$TEQ_{P,M}$ concentrations are highest in samples collected from within the 1966 perimeter of the impoundments north of I-10, with the maximum value of 38.1 ng/kg from the 4- to 6-foot depth interval in core SJGB012 (Figure 15). The $TEQ_{P,M}$ concentrations in most surface and subsurface samples within the northern impoundment exceed 1 ng/kg, while all but two values outside of the northern impoundment are below 1 ng/kg. The exceptions are one surface and one subsurface sample location along the northwest portion of the peninsula south of I-10. These are in the surface interval at Station SJSD004 (6.85 ng/kg), and in the 12- to 24-inch depth interval of SJSD002 (1.58 ng/kg).

Data for PCB congeners in subsurface samples outside of the northern impoundments are not available, so concentrations of $TEQ_{P,M}$ adjacent to the upland sand separation area, north of the northern impoundments, and elsewhere are not described.

Tissue TEQ_{DF}

Tissue samples were collected from three site fish collection areas (FCAs) presented on Figure 16:

- FCA 1 – Downstream of I-10 (identified as SJFCA1 on Figure 16)
- FCA 2 – In the area surrounding the impoundments north of I-10 and the upland sand separation area (identified as SJFCA2 on Figure 16)
- FCA 3 – Upstream of the northern impoundments and upland separation area (identified as SJFCA3 on Figure 16).

Dioxins and furans were generally detected in tissue samples collected at the site and from background locations. In some samples, many congeners were never detected. Data for blue crab, hardhead catfish, clams, and Gulf killifish are summarized in this section.

Mean TEQ_{DF} results in edible blue crab tissue range from 0.146 ng/kg at FCA 3 to 0.739 ng/kg in FCA 1 (Table 8). Means for edible crab tissue in FCA 2 and FCA 3 at 0.23 and 0.146 ng/kg, respectively, are closer to the background mean (0.157 ng/kg) than to the mean in FCA 1. In all FCAs, 2,3,7,8-TCDF has the highest mean and the highest individual concentrations among the dioxin and furan congeners in crab tissue.

Mean TEQ_{DF} results in hardhead catfish fillet range from 2.94 in FCA 1 to 3.87 ng/kg in FCA 2 with the highest mean and the highest maximum in FCA 2 (Table 9). The overall range of TEQ_{DF} concentrations in catfish fillet from FCAs 1 through 3 is 0.801 ng/kg in FCA 1 to 5.85 ng/kg in FCA 2, with the three maximum values for the three FCAs being fairly similar.

Edible clam (common rangia) tissues had the highest mean and maximum TEQ_{DF} results within the site perimeter, with both the highest mean and the highest maximum in FCA 2. The mean TEQ_{DF} in clams in FCA 2 is 7.89 ng/kg, where the maximum TEQ_{DF} is 27 ng/kg, nearly as high as the maxima for whole catfish in FCA 1 and FCA 2. In addition, all but three dioxin and furan congeners were detected at least once in FCA 2; in all other areas (including background), the same four congeners were detected in clams: 2,3,7,8-TCDD, 1,2,3,4,6,7,8- heptachlorodibenzo-p-dioxin (HpCDD), 2,3,7,8-TCDF, and OCDD (Table 10). Other congeners were never detected in clams from FCA 1 and FCA 3 nor in clams from upstream.

Dioxins and furans were never detected in killifish samples from FCA 1, and only two dioxin congeners (1,2,3,4,6,7,8-HpCDD and OCDD) and one furan congener (2,3,7,8-TCDF) were detected in killifish from FCA 3 (Table 11). A total of seven dioxin and furan congeners (2,3,7,8-TCDD, 1,2,3,4,6,7,8-HpCDD, OCDD, 2,3,7,8-TCDF, 2,3,4,7,8-pentachlorodibenzo-furan, 1,2,3,4,7,8-hexachlorodibenzofuran [HxCDF], and 1,2,3,6,7,8-HxCDF) were detected in killifish from FCA 2. The maximum TEQ_{DF} concentration in killifish (10.1 ng/kg) was in killifish from FCA 2.

Tissue PCBs

As described above, tissue samples were collected from three site FCAs (Figure 16). PCBs were detected in all edible and whole crab samples, including those from background. Like dioxins and furans, total PCB concentrations (as the sum of all congeners with nondetects set to one-half the detection limit) are higher in whole crab than in edible crab (Table 8). Among edible crab samples, background minimum, maximum, and mean total PCB concentrations are 0.55 µg/kg, 2.1 µg/kg, and 1.29 µg/kg, respectively. At the site, mean total PCB concentrations in edible crab tissue range from 2.0 µg/kg in FCA 1 to 7.4 µg/kg in FCA 2. Similarly, the highest mean $TEQ_{P,M}$ occurs in FCA 2, where the overall maximum $TEQ_{P,M}$ also occurs. The spatial pattern of PCBs in crab is therefore different from that of dioxins and furans as TEQ_{DF} for which the highest concentrations in crab tissue are in FCA 1.

PCBs were detected in all catfish samples (Table 9). Total PCB concentrations are higher in whole catfish tissue samples than in catfish fillet, both from at the site and in Cedar Bayou. Total PCBs in Cedar Bayou catfish fillet samples range from 25.5 to 88.4 µg/kg, with a mean total PCB concentration of 46.5 µg/kg. At the site, the mean total PCB concentrations in catfish fillet ranges from 97.7 µg/kg in FCA 1 to 107 µg/kg in FCA 3. The smallest range in total PCB concentrations in catfish fillet occurs in FCA 2, which has the highest minimum among the FCAs. Mean and median total PCB concentrations in catfish tissue samples from all three FCAs are greater than those in catfish collected from the Cedar Bayou background sampling area.

In contrast to TEQ_{DF} in catfish fillet tissue, the highest maximum and mean concentrations for $TEQ_{P,M}$ are in fish from FCA 3 at 2.79 ng/kg and 1.36 ng/kg, respectively. Patterns are similar for whole catfish, except the highest maximum is in FCA 3 while the highest mean is in FCA 1. In whole catfish from all three FCAs, differences in the $TEQ_{P,M}$ concentrations at the site relative to those from Cedar Bayou are much smaller than the differences between these two locations for TEQ_{DF}.

PCBs were detected in all edible clam tissue samples, including background (Table 10). At the site, mean total PCB concentrations ranges from 23.6 µg/kg in FCA 1 to 46.1 µg/kg in FCA 2. The range is 20.2 µg/kg in FCA 2 to 95.4 µg/kg in FCA 2. Background minimum, maximum, and mean total PCB concentrations are 9.54 µg/kg, 17.8 µg/kg, and 12.9 µg/kg, respectively.

Concentrations of $TEQ_{P,M}$ are generally lower in clams than those of TEQ_{DF}. The mean $TEQ_{P,M}$ is higher in FCA 2 (0.502 ng/kg) than its mean in FCA 1 (0.22 ng/kg) or FCA 3 (0.366 ng/kg). The same pattern holds for maximum values within the three FCAs (Table 10). Clams from FCA 1 have the lowest maximum (0.271 ng/kg) and the lowest median (0.225 ng/kg) $TEQ_{P,M}$ concentrations. In comparison, the minimum, maximum, and mean upstream background $TEQ_{P,M}$ concentrations are 0.118 ng/kg, 0.283 ng/kg, and 0.181 ng/kg, respectively. Concentrations of $TEQ_{P,M}$ in clams (and killifish) are not significantly different in FCA 1 than in the upstream background area.

PCBs were detected in all Gulf killifish tissue samples, including in upstream background samples (Table 11). At the site, mean total PCB concentrations range from 36.2 µg/kg in FCA 1 to 82.6 µg/kg in FCA 2. The maximum $TEQ_{P,M}$ concentration in killifish (2.92 ng/kg) is also for FCA 2. Background minimum, maximum, and mean total PCB concentrations are 10.2 µg/kg, 14.6 µg/kg, and 12 µg/kg, respectively. Mean total PCB concentrations detected Gulf killifish tissue samples at the site are significantly greater than in background Gulf killifish tissue, but $TEQ_{P,M}$ is not significantly different in FCA 1 or FCA 3 than in background.

South of I-10 Soil

TEQ_{DF} concentrations in surface soil from Soil Investigation Area 4 and adjacent sampled areas range from 1.35 to 36.9 ng/kg (Table 12). TEQ_{DF} concentrations above 30 ng/kg in surface soil occur at both the southern (Stations SJSB023 and SJSB024) and northern (Stations SJSB001 and SJSB014) ends of Soil Investigation Area 4 (Figure 17). These are the only locations where TEQ_{DF} in surface soils exceeds the surface soil reference envelope value for this parameter of 24.3 ng/kg. Substantially lower concentrations including the minimum TEQ_{DF} concentration of 1.35 ng/kg are found at stations in close proximity to those that exceed the surface soil reference envelope value, indicating that these few slightly elevated TEQ_{DF} concentrations are localized. The average surface soil TEQ_{DF} in Soil Investigation Area 4 and adjacent areas is most similar to that of Soil Investigation Area 2, beneath I-10, in the TxDOT Right-of-Way (Table 1). Within Soil Investigation Area 4, the congener with the highest concentration in surface soil is OCDD, at 64,900 ng/kg (Table 12). TCDD concentrations range up to 24.3 ng/kg.

In subsurface soils from 6 to 24 inches, TEQ_{DF} results range from 0.134 to 303 ng/kg, with an average of 16.5 ng/kg (Figure 17). The second highest result in this depth interval (43.1 ng/kg at Station SJSB018) is much lower than the maximum (Figure 17). The average TEQ_{DF} result in subsurface soils from 6 to 24 inches deep is slightly greater in the area of investigation on the peninsula south of I-10 than in Soil Investigation Area 1, which includes the upland sand separation area and the nearby access road north of I-10 (Table 2). As for surface soils, the congener with the highest results in subsurface soils collected south of I-10 is OCDD at 106,000 ng/kg (Table 13).

TEQ_{DF} results deeper than 2 feet range from 0.092 to 50,100 ng/kg and average 743 ng/kg (Table 14). The maximum core TEQ_{DF} occurs at a depth of 6 to 8 feet and is at Station SJSB019 in the southern part of soil investigation area 4 (Figure 17). Station SJSB023 has the second-highest TEQ_{DF} concentration (35,500 ng/kg, at depth interval of 4 to 6 feet [Figure 17]); the highest concentration in surface soils is also found at this location. The majority of the highest core TEQ_{DF} concentrations occur between 6 and 12 feet deep, and are associated with stations located near the center of the peninsula south of I-10.

South of I-10 Groundwater

Three or more dioxin and furan congeners were detected in all three monitoring wells south of I-10. For those that were detected, the highest concentrations consistently occur in SJMW001. The TEQ_{DF} result in SJMW001 was 47.3 pg/L. The average concentration of 2,3,7,8-TCDD in all wells is 17.1 pg/L (using the estimated result in SJMW002 of 8.92 pg/L and the detection limit in SJMW003 of 9.9 pg/L). Table 15 presents summary statistics for groundwater samples collected south of I-10 as documented in the RI report (Integral and Anchor 2013a).

Additional groundwater samples were collected from three wells installed in 2013 as documented in the RI Addendum 1 (Anchor and Integral 2013). The TEQ_{DF} result in SJMW004S was an estimated 60.2 pg/L. Conclusions of the RI Addendum include that "…none of the groundwater sampled in Soil Investigation Area 4 are Class 1 groundwater resources according to the classification system used in Texas; only Class 2 and Class 3 groundwaters are present…" and that "..there is no evidence that chemicals potentially associated with paper mill wastes in the area of investigation on the peninsula south of I-10 could be transported to drinking water or to the aquatic environment" (Anchor and Integral 2013).

2.5.4 *Chemical Fate and Transport*

Section 5.6 of the RI Report contains a summary of the chemical fate and transport processes affecting the concentrations of dioxins and furans at the site. The most significant points of this discussion are summarized in the FS (EPA 2016) and are provided below:

- Sediment-water interactions – Dioxins and furans are hydrophobic and preferentially bind to particulate matter. Particulate-associated dioxins and furans within the sediment bed enter the water column through sediment deposition and erosion processes. Deposition of sediments with low concentrations of chemicals may support natural recovery.

- Partitioning and dissolved phase flux – Because dioxins and furans are hydrophobic, they will be present primarily in particulate form, and their fate is therefore determined largely by sediment transport processes. Dioxins and furans within the sediment matrix include dissolved-phase dioxins and furans in porewater through partitioning processes, which can result in a transfer of dissolved-phase mass to the water column under certain conditions.

- Transport in the water column – Dioxins and furans present in the water column in any phase are transported by surface water currents, which are affected by hydrodynamic processes within the larger San Jacinto River.

- External sources – Publicly owned treatment plant outfalls, other point-source discharges, stormwater runoff, and atmospheric deposition are all sources of dioxins and furans. As documented in the RI Report, groundwater is not a source of dioxins or furans to the San Jacinto River.

It should also be noted that data analyses and literature review, including evaluation of region-specific multivariate datasets, indicates that the majority of dioxin and furan congeners do not consistently bioaccumulate in fish or invertebrate tissue. This is due to biological controls on uptake and excretion in both fish and invertebrates (Integral 2010). As a result, systematic predictions of bioaccumulation from concentrations of dioxins and furans in abiotic media (both sediment and water) are only possible for tetrachlorinated congeners. However, even these correlations are weak, and are associated with high uncertainty (Integral 2010).

2.6 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

This section summarizes the current and reasonably anticipated future land and resource use at the site and surrounding the site. This information forms the basis for the exposure assessment assumptions and risk characterization conclusions discussed in Section 2.7.

2.6.1 *Land Use*

Current land use at the site is primarily industrial and commercial use, as presented on Figure 18. Current land use surrounding the site includes mixed residential and industrial uses to the west, and undeveloped or residential areas to the east and north. Immediately south of the site is commercial/industrial land use. Moving farther from the site, the amount of residential land use increases, along with other land use categories not found in the immediate vicinity, such as undeveloped land, farms, parks, and lands listed as “other” (e.g., schools and hospitals). The future land use is not anticipated to be different from the current land use.

2.6.2 *Surface Water Use*

The San Jacinto River watershed encompasses nearly 4,000 square miles and approximately 310 miles of open streams including primary streams and tributary channels. The San Jacinto River flows from its headwaters near Huntsville, Texas through Lake Conroe and Lake Houston. The Port of Houston Authority operates the Houston Ship Channel, which originates at the Turning Basin on Buffalo Bayou and follows to the San Jacinto River. The Houston Ship Channel continues through the San Jacinto River and San Jacinto Bay to Galveston Bay.

The area south of the site is dominated by activities associated with the Houston Ship Channel, specifically industrial sites that are served by the barges and ocean-going vessels that use the Houston Ship Channel. From the site north to Lake Houston, there is less industrialization along the river.

Harvesting Shellfish and Fish

Commercial and recreational fishing activity occurs throughout Galveston Bay. The San Jacinto River along with nearby Upper Galveston Bay, Tabbs Bay, and the San Jacinto State Park have "many points of public access and support both recreational and subsistence fishing activities" (Texas Department of State Health Services [TDSHS] 2005). Near the site, fishing is known to occur, however the amount and frequency of fishing has not been determined (Integral and Anchor 2013a). No known subsistence fishing communities have been documented in the area.

Consumption of mollusks and shellfish (clams, mussels, and oysters) taken from public fresh waters is prohibited by TDSHS. Within public salt waters, these shellfish may be taken only from waters approved by TDSHS. TDSHS shellfish harvest maps designate approved or conditionally approved harvest areas. Waters near the site are not included on these maps (TPWD 2009).

Other Recreational Use

Although the site is private land, access points along the San Jacinto River allow for a variety of recreational activities including picnicking, swimming, nature walks, bird watching, wading, fishing, boating, water sports, and other shoreline uses. In the area to the south of the I-10 Bridge on the west side of the river, children and adults have been reported to at times play along the shoreline, wade in the water, and fish (Integral and Anchor 2013a).

Potable Surface Water Use

There are no surface water intakes within 15 miles downstream of the northern impoundments or of the peninsula south of I-10 (TCEQ 2006).

2.7 SUMMARY OF SITE RISKS

The BHHRA and baseline ecological risk assessments (BERAs) were conducted to determine potential pathways by which people (human receptors) or animals (ecological receptors) could be exposed to upland or aquatic contamination in sediment, soil, water, or biota, the amount of contamination receptors of concern may be exposed to, and the toxicity of those contaminants if no action were taken to address contamination at the site (Integral and Anchor 2013b, Integral 2013, Appendix D of Integral and Anchor 2013a). The risk assessments were conducted on the baseline conditions that existed before the installation of the temporary cap over the northern waste pits that was completed during a removal action. This temporary cap was built to stabilize the northern waste pits and prevent direct human exposures until a permanent remedy could be selected for the Site. These assessments provide the basis for taking action and identify the contaminants and exposure pathways that need to be addressed by the remedial action. Section 2.7.1 provides a summary of the relevant portions of the BHHRA as summarized from Integral and Anchor (2013b). Section 2.7.2 provides a summary of the relevant portions of the BERAs as summarized from Integral (2013) and Integral and Anchor (2013a). Section 2.7.3 discusses the basis for action at the site.

2.7.1 *Summary of Human Health Risk Assessment*

The baseline risk assessment estimates what risks the site poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the SIP summarizes the results of the BHHRA.

Identification of Chemicals of Concern

The tables below present the COCs and exposure point concentrations for each of the COCs detected in media (i.e., the concentration that will be used to estimate the exposure and risk from each COC). The tables include the number of samples per exposure unit, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration, and how the exposure point concentration was derived.

Chemicals of Concern and Baseline Exposure Point Concentrations North of I-10 and Aquatic Environment

Scenario Timeframe: Baseline						
Exposure Unit	**Chemical of Concern**	**Number of Samples**	**Maximum Result (ng/kg)**	**Frequency of Detection (percent)**	**Exposure Point Concentration (ng/kg)**	**Statistical Measure**
Sediment						
Beach Area A	TEQ_{DF}(ND=1/2)	5	0.495	100	0.456	95UCL
	TEQ_{DF}(ND=0)	5	0.373	100	0.339	95UCL
	Aroclors(ND=1/2)	Not Sampled	--	--	--	--
	Aroclors(ND=0)	Not Sampled	--	--	--	--
	TEQ_P(ND=1/2)	Not Sampled	--	--	--	--
	TEQ_P(ND=0)	Not Sampled	--	--	--	--
Beach Area B/C	TEQ_{DF}(ND=1/2)	10	10.9	100	6.36	95UCL
	TEQ_{DF}(ND=0)	10	10.7	100	6.12	95UCL
	Aroclors(ND=1/2)	Not Sampled	--	--	--	--
	Aroclors(ND=0)	Not Sampled	--	--	--	--
	TEQ_P(ND=1/2)	Not Sampled	--	--	--	--
	TEQ_P(ND=0)	Not Sampled	--	--	--	--
Beach Area D	TEQ_{DF}(ND=1/2)	7	2.9	100	2.12	95UCL
	TEQ_{DF}(ND=0)	7	2.8	100	2.0	95UCL
	Aroclors(ND=1/2)	Not Sampled	--	--	--	--
	Aroclors(ND=0)	Not Sampled	--	--	--	--
	TEQ_P(ND=1/2)	Not Sampled	--	--	--	--
	TEQ_P(ND=0)	Not Sampled	--	--	--	--
Beach Area E	TEQ_{DF}(ND=1/2)	17	47,000	100	13,000	95UCL
	TEQ_{DF}(ND=0)	17	46,000	100	13,000	95UCL
	Aroclors(ND=1/2)	4	1,400,000	0	1,400,000	Max A 1254
	Aroclors(ND=0)	4	0	0	0	Max
	TEQ_P(ND=1/2)	4	4.5	100	4.5	Max
	TEQ_P(ND=0)	4	2.43	100	2.35	95UCL
Tissue – Hardhead Catfish Fillet						
FCA 1	TEQ_{DF}(ND=1/2)	10	5.45	100	3.92	95UCL
	TEQ_{DF}(ND=0)	10	5.32	100	3.86	95UCL
	PCB_C(ND=1/2)	12	156,000	100	104,000	95UCL
	PCB_C(ND=0)	12	156,000	100	104,000	95UCL
	TEQ_P(ND=1/2)	12	2.27	100	1.67	95UCL
	TEQ_P(ND=0)	12	2.17	100	1.43	95UCL
FCA 2/3	TEQ_{DF}(ND=1/2)	20	5.85	100	4.06	95UCL
	TEQ_{DF}(ND=0)	20	5.84	100	3.99	95UCL
	PCB_C(ND=1/2)	20	129,000	100	94,200	95UCL
	PCB_C(ND=0)	20	129,000	100	94,200	95UCL
	TEQ_P(ND=1/2)	20	2.79	100	1.57	95UCL
	TEQ_P(ND=0)	20	2.7	100	2.38	95UCL

Chemicals of Concern and Baseline Exposure Point Concentrations North of I-10 and Aquatic Environment (Continued)

Scenario Timeframe: Baseline						
Exposure Unit	**Chemical of Concern**	**Number of Samples**	**Maximum Result (ng/kg)**	**Frequency of Detection (percent)**	**Exposure Point Concentration (ng/kg)**	**Statistical Measure**
Tissue – Edible Clam						
FCA 1/3	TEQ_{DF}(ND=1/2)	10	2.19	100	1.65	95UCL
	TEQ_{DF}(ND=0)	10	2.12	100	1.51	95UCL
	PCB_C(ND=1/2)	10	26,900	100	21,700	95UCL
	PCB_C(ND=0)	10	26,900	100	21,600	95UCL
	TEQ_P(ND=1/2)	10	0.436	100	0.346	95UCL
	TEQ_P(ND=0)	10	0.104	100	0.0802	95UCL
FCA 2	TEQ_{DF}(ND=1/2)	15	27	100	19	95UCL
	TEQ_{DF}(ND=0)	15	26.9	100	21.4	95UCL
	PCB_C(ND=1/2)	15	61,800	100	50,000	95UCL
	PCB_C(ND=0)	15	61,800	100	50,000	95UCL
	TEQ_P(ND=1/2)	15	1.9	100	0.824	95UCL
	TEQ_P(ND=0)	15	0.787	100	0.442	95UCL
Tissue – Edible Crab						
FCA 1	TEQ_{DF}(ND=1/2)	10	1.91	100	1.07	95UCL
	TEQ_{DF}(ND=0)	10	1.85	100	0.972	95UCL
	PCB_C(ND=1/2)	10	4,820	100	3,350	95UCL
	PCB_C(ND=0)	10	4,740	100	3,290	95UCL
	TEQ_P(ND=1/2)	10	0.234	100	0.148	95UCL
	TEQ_P(ND=0)	10	0.0271	100	0.0201	95UCL
FCA 2/3	TEQ_{DF}(ND=1/2)	20	0.558	60	0.286	95UCL
	TEQ_{DF}(ND=0)	20	0.523	60	0.176	95UCL
	PCB_C(ND=1/2)	20	11,400	100	7,170	95UCL
	PCB_C(ND=0)	20	11,300	100	7,130	95UCL
	TEQ_P(ND=1/2)	20	0.547	100	0.296	95UCL
	TEQ_P(ND=0)	20	0.525	100	0.186	95UCL
Soil						
North of I-10	TEQ_{DF}(ND=1/2)	46	153	100	22.6	95UCL
	TEQ_{DF}(ND=0)	46	152	100	23.8	95UCL
	Aroclors(ND=1/2)	15	130,000	26.7	48,400	95UCL
	Aroclors(ND=0)	15	130,000	26.7	48,400	95UCL
	TEQ_P(ND=1/2)	12	2.83	91.7	2.65	95UCL
	TEQ_P(ND=0)	12	2.83	91.7	2.83	Max

Note:
95UCL – 95 percent upper confidence limit
FCA – fish collection area
Max – maximum result
Max A 1254 – maximum result of Aroclor 1254
ND=0 – nondetect results assumed equal to zero in TEQ calculation
ND=1/2 – nondetect results assumed equal to ½ the detection limit in TEQ calculation
ng/kg – nanograms per kilogram
PCB_C – sum of 43 PCB congeners
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient
TEQ_P – toxicity equivalent for dioxin-like polychlorinated biphenyls

Chemicals of Concern and Baseline Exposure Point Concentrations South of I-10

Exposure Unit	Chemical of Concern	Number of Samples	Maximum Result (ng/kg)	Frequency of Detection (percent)	Exposure Point Concentration (ng/kg)	Statistical Measure
Scenario Timeframe: Baseline						
Surface Soil						
0-6 Inches	TEQ_{DF}(ND=1/2)	26	36.9	100	27.9	95UCL
	TEQ_{DF}(ND=0)	26	36.9	100	28.2	95UCL
Surface and Shallow Subsurface Soil						
0-12 Inches	TEQ_{DF}(ND=1/2)	26	36.9	100	24.6	95UCL
	TEQ_{DF}(ND=0)	26	36.9	100	24.7	95UCL
Surface and Deep Subsurface Soils (0-10 Feet)						
DS-1	TEQ_{DF}(ND=1/2)	--	--	--	2,400	--
	TEQ_{DF}(ND=0)	--	--	--	2,400	--
DS-2	TEQ_{DF}(ND=1/2)	--	--	--	10,900	--
	TEQ_{DF}(ND=0)	--	--	--	10,900	--
DS-3	TEQ_{DF}(ND=1/2)	--	--	--	5.94	--
	TEQ_{DF}(ND=0)	--	--	--	5.71	--
DS-4	TEQ_{DF}(ND=1/2)	--	--	--	7,770	--
	TEQ_{DF}(ND=0)	--	--	--	7,770	--
DS-5	TEQ_{DF}(ND=1/2)	--	--	--	552	--
	TEQ_{DF}(ND=0)	--	--	--	552	--

Note:
-- - information unavailable
95UCL – 95 percent upper confidence limit
ND=0 – nondetect results assumed equal to zero in TEQ calculation
ND=1/2 – nondetect results assumed equal to ½ the detection limit in TEQ calculation
ng/kg – nanograms per kilogram
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

Exposure Assessment

Exposure pathways quantitatively evaluated in the BHHRA for the area north of I-10 and aquatic environment included the following:

- Recreational Fisher – direct contact (incidental ingestion and dermal contact) with sediment and soils, ingestion of finfish, and ingestion of shellfish
- Subsistence Fisher – direct contact (incidental ingestion and dermal contact) with sediment and soils, ingestion of finfish, and ingestion of shellfish
- Recreational Visitor – direct contact (incidental ingestion and dermal contact) with sediment and soils.

Exposure pathways for the area north of I-10 and aquatic environment are presented in the conceptual site model (Figure 6) and discussed in Section 5.1.1 of the BHHRA. Both recreational and subsistence fishers are assumed to ingest fish and/or shellfish caught at the site. Table 16 provides exposure parameter assumptions used for the area north of I-10 and the aquatic environment. Recreational fishers are assumed to ingest 25 percent of total fish or shellfish intake that is site-related (Table 16). Subsistence fishers are assumed to ingest 100 percent of total fish or shellfish intake that is site-related (Table 16). In the absence of detailed information regarding fishing activities and consumption patterns in the area, exposures were estimated using three scenarios: 1) ingestion of finfish only, 2) ingestion of clams only, and 3) ingestion of crabs only. Assuming a single-tissue type exposure is a conservative approach because it identifies and quantifies potential exposure to the tissue type that may result in the highest potential for exposure (Integral and Anchor 2013b). Cumulative exposures (i.e., ingestion and dermal contact) were summed for each tissue ingestion scenario separately by exposure area. Baseline sediment, tissue, and soil exposure areas are presented on Figures 19 through 21, respectively. Table 17 provides a complete set of hypothetical exposure scenarios evaluated for the baseline condition.

Exposure pathways quantitatively evaluated in the BHHRA for the area south of I-10 included the following:

- Trespasser – direct contact (incidental ingestion and dermal contact) with surface soil

- Commercial Worker – direct contact (incidental ingestion and dermal contact) with surface and shallow subsurface soil

- Future Construction Worker – direct contact (incidental ingestion and dermal contact) with surface and subsurface soil.

Exposure pathways for the area south of I-10 are presented in the conceptual site model (Figure 8) and discussed in Section 6.1.1 of the BHHRA (Integral and Anchor 2013b). Exposure to future construction workers was evaluated using five 0.5-acre exposure units. Table 18 provides exposure parameter assumptions used for the area south of I-10.

The potential inhalation of dioxins and furans in air and exposure via direct contact with surface water were identified as minor exposure pathways and only addressed qualitatively. Inhalation exposure via vapor is considered minor because dioxins and furans are not volatile compounds and therefore would not tend to volatilize into air. Inhalation of particulates derived from the resuspension of surface soil may occur; however this pathway generally contributes less than one percent of total estimated exposure when direct soil contact pathways (ingestion and dermal contact) are considered. Exposure to dioxins and furans in surface water is also considered to be a minor pathway because they are hydrophobic (not soluble in water), and tend to be bound to organic carbon in sediment. It is possible suspended sediment particles in the water column could come in contact with human receptors; however, those exposures are assumed to be brief and minimal because the movement of surface water would likely wash away the majority of sediment particles that contact the skin.

Toxicity Assessment

The tables below provide the carcinogenic and noncarcinogenic risk information relevant to COCs in sediment, soil, and tissue that was used in the BHHRA (Integral and Anchor 2013b).

Cancer Toxicity Data

Chemical of Concern	Provisional Tolerable Oral Daily Intake / Oral Cancer Slope Factor	Units	Weight of Evidence/Cancer Guideline Description	Date of Most Recent Update
TEQ_{DF} [1]	2.3	pg/kg-day	B2- probable human carcinogen, sufficient evidence in animals and inadequate or no evidence in humans	2002
Polychlorinated Biphenyls[2]	2.0	mg/kg-day	B2- probable human carcinogen, sufficient evidence in animals and inadequate or no evidence in humans	1997

Note:
[1] 2,3,7,8-TCDD values were used to evaluate TEQ_{DF}. It is based on the Joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives (2002) recommended provisional tolerable monthly intake for all potential health effects including cancer, adjusted to reflect a daily intake as discussed in the BHHRA (Integral and Anchor 2013b).
[2] Information presented was used in the reasonable maximum exposure calculations of the BHHRA, different values were used for central tendency exposure.
BHHRA – baseline human health risk assessment
mg/kg – milligrams per kilogram
pg/kg – picograms per kilogram
TCDD – tetrachlorodibenzo-p-dioxin
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

Noncancer Toxicity Data

Chemical of Concern	Chronic			Subchronic			Primary Target Organ	Date of Most Recent Update
	Oral RfD Value (pg/kg-day)	Source	Combined Uncertainty/ Modifying Factors	Oral RfD Value (pg/kg-day)	Source	Combined Uncertainty/ Modifying Factors		
TEQ_{DF}[1]	0.7	IRIS	30	0.7	IRIS[2]	30	Reproductive/ Developmental Issues	2/17/2012
Polychlorinated Biphenyls[3]	20,000	IRIS	300	60,000	calculated[4]	100	Immune System	11/1/1996

Note:
[1] 2,3,7,8-TCDD values were used to evaluate TEQ_{DF}.
[2] no subchronic RfD was available, the chronic RfD was selected.
[3] Values for Aroclor 1254 presented. Aroclor 1254 was the only Aroclor detected at the site.
[4] Derivation of the chronic RfD included a factor adjust for less than lifetime exposure. This value was removed to derive the subchronic exposure.
IRIS – Integrated Risk Information System
pg/kg – picograms per kilogram
RfD – reference dose
TCDD – tetrachlorodibenzo-p-dioxin
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

Relative Oral Bioavailability

Bioavailability refers to the degree to which a substance becomes available to the target tissue after administration or exposure (EPA 2012b). Relative bioavailability is a measure of the extent of absorption that occurs for different forms of the same chemical, different dosing vehicles, or different dose levels. Relative bioavailability adjustment factors, or RBA factors, for oral pathways are used to account for the differences in chemical bioavailability in specific exposure media (i.e., soil, sediment, tissue) compared to the dosing vehicle used in the critical toxicity study that provides the basis for the COPC-specific toxicity criteria selected for use. The RBA factor used for ingestion of sediment and soil for dioxins and furans in the BHHRA was 0.5 (Integral and Anchor 2013b). However, the values presented in this SIP have been adjusted for use of a RBA factor of 1.0, therefore the BHHRA table values will not match those presented in this SIP.

Risk Characterization

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

$$\textbf{Risk = CDI x SF}$$

where

risk = a unitless probability (e.g., $2x10^{-5}$) of an individual's developing cancer as a result of site-related exposure

CDI = chronic daily intake averaged over 70 years (picograms per kilogram [pg/kg]-day)

SF = slope factor, expressed as $(pg/kg\text{-}day)^{-1}$.

These risks are probabilities that usually are expressed in scientific notation (e.g., $1x10^{-6}$). An excess lifetime cancer risk of $1x10^{-6}$ indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual's developing cancer from other causes has been estimated to be as high as one in three. EPA's generally acceptable risk range for site-related exposures is 10^{-4} to 10^{-6}.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., life-time) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The HI is generated by adding the HQs for all COCs that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI<1 indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic noncarcinogenic effects from contaminants are unlikely. An HI>1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

Non-cancer HQ = CDI/RfD

where,

CDI = chronic daily intake

RfD = reference dose.

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

For some carcinogens (e.g., dioxins and furans), a threshold or minimum dose must be reached before a carcinogenic effect can occur. For these carcinogens, the potential for cancer to occur as a result of the assumed exposure is estimated using a hazard metric like that described for noncancer hazards above (Integral and Anchor 2013b). The BHHRA (Integral and Anchor 2013b) evaluated both cancer risks and cancer hazards for dioxins and furans. Additional discussion of this topic can be found in the *Toxicological and Epidemiological Studies Memorandum* (Integral 2012; Appendix B of the BHHRA).

The text and tables below provide a summary of site related noncancer HIs above 1 and cancer HIs above 1. There were no cancer risks above 1×10^{-4} identified in the BHHRA (Integral and Anchor 2013b). HIs presented below are based on calculations of reasonable maximum exposure. Reasonable maximum exposure is defined as the highest exposure that could be reasonably anticipated to occur for a given exposure pathway and scenario at the site. Central tendency exposure, or the average estimate of exposure, was also evaluated in the BHHRA (Integral and Anchor 2013b); however it will not be included here for brevity.

The deterministic risk assessment for a recreational fisher north of I-10 and the aquatic environment is presented in Section 5.2.2.1 of the BHHRA (Integral and Anchor 2013b) and is summarized below. For a recreational fisher in Exposure Scenarios 3A, 3B, and 3C (direct exposure to Beach Area E and the ingestion of catfish, clam, or crab from the fishing areas identified), the reproductive/developmental noncancer HIs are greater than one and indicate a potential for adverse noncancer effects. The table below provides noncancer HQs for exposure to sediment and fish or shellfish for all scenarios with endpoint-specific HIs greater than one for recreational fisher exposure scenarios.

North of I-10 and the Aquatic Environment Noncancer Hazards for a Recreational Fisher

Scenario Timeframe:	Baseline
Receptor Population:	Recreational Fisher
Receptor Age:	Young Child
Calculation Assumption:	Reasonable Maximum Exposure

		Noncancer Hazard Quotient			
Chemical[1]	**Primary Target Organ**	**Incidental Ingestion of Sediment**	**Dermal Contact with Sediment**	**Consumption of Fish or Shellfish[2]**	**Exposure Route Total[3]**
Scenario 1A: Direct Exposure Beach Area A; Ingestion of Catfish from FCA 2/3					
TEQ_{DF}	Reproductive/Developmental	0.00046	0.0013	**1.1**	**1.1**
Methylmercury[4]	Reproductive/Developmental	--	--	0.27	0.27
				Reproductive/Developmental Endpoint-Specific Hazard Index	**1.4**
Scenario 2A: Direct Exposure Beach Area B/C; Ingestion of Catfish from FCA 2/3					
TEQ_{DF}	Reproductive/Developmental	0.0064	0.018	**1.1**	**1.1**
Methylmercury[4]	Reproductive/Developmental	--	--	0.27	0.27
				Reproductive/Developmental Endpoint-Specific Hazard Index	**1.4**
Scenario 3A: Direct Exposure Beach Area E; Ingestion of Catfish from FCA 2/3					
TEQ_{DF}	Reproductive/Developmental	**13**	**37**	**1.1**	**51**
Methylmercury[4]	Reproductive/Developmental	--	--	0.27	0.27
				Reproductive/Developmental Endpoint-Specific Hazard Index	**51**
PCBs	Immune	0.049	0.65	0.88	**1.6**
Inorganic Mercury[4]	Immune	0.0047	0.013	--	0.02
				Immune Endpoint-Specific Hazard Index	**1.6**
Scenario 3B: Direct Exposure Beach Area E; Ingestion of Clam from FCA 2					
TEQ_{DF}	Reproductive/Developmental	**13**	**37**	0.21	**50**
Methylmercury[4]	Reproductive/Developmental	--	--	0.0009	0.0009
				Reproductive/Developmental Endpoint-Specific Hazard Index	**50**
Scenario 3C: Direct Exposure Beach Area E; Ingestion of Crab from FCA 2/3					
TEQ_{DF}	Reproductive/Developmental	**13**	**37**	0.0032	**50**
Methylmercury[4]	Reproductive/Developmental	--	--	0.003	0.003
				Reproductive/Developmental Endpoint-Specific Hazard Index	**50**
Scenario 4A: Direct Exposure Beach Area D; Ingestion of Catfish from FCA 1					
TEQ_{DF}	Reproductive/Developmental	0.0022	0.006	**1.0**	**1.0**
Methylmercury[4]	Reproductive/Developmental	--	--	0.36	0.36
				Reproductive/Developmental Endpoint-Specific Hazard Index	**1.4**

Note:
[1] All chemicals with primary target organ exposure route totals greater than 1 are included in this table.
[2] See scenario title for identification of tissue consumed
[3] Two significant figures presented, differences between values presented in the risk assessment tables and those presented here are either a result of the use of a relative bioavailability factor of 1.0, the number of significant figures presented, rounding, or a combination of all three.
[4] Consistent with EPA guidance (2010c), 100 percent of mercury detected in tissue was assumed to be methylmercury and 100 percent of mercury detected in soil and sediment was assumed to be inorganic mercury.
FCA – fish collection area
PCB – polychlorinated biphenyls
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

The deterministic risk assessment for a recreational fisher north of I-10 and the aquatic environment is presented in Section 5.2.2.1 of the BHHRA (Integral and Anchor 2013b) and is summarized below. For a recreational fisher in Exposure Scenarios 3A, 3B, and 3C (direct exposure to Beach Area E and the ingestion catfish, clam, or crab from the fishing areas identified), the TEQ_{DF} cancer HIs are greater than one and indicate a potential for cancer. The table below provides TEQ_{DF} cancer HIs for recreational fisher exposure scenarios that are greater than one.

North of I-10 and the Aquatic Environment Cancer Hazards for a Recreational Fisher

Scenario Timeframe:	Baseline			
Receptor Population:	Recreational Fisher			
Receptor Age:	Lifetime			
Calculation Assumption:	Reasonable Maximum Exposure			
	TEQ_{DF} Cancer Hazard Quotient[1]			
Chemical of Concern	**Incidental Ingestion of Sediment**	**Dermal Contact with Sediment**	**Consumption of Fish or Shellfish[2]**	**Total[3]**
Scenario 3A: Direct Exposure Beach Area E; Ingestion of Catfish from FCA 2/3				
TEQ_{DF}	**4.0**	**11**	0.33	**15**
Scenario 3B: Direct Exposure Beach Area E; Ingestion of Clam from FCA 2				
TEQ_{DF}	**4.0**	**11**	0.065	**15**
Scenario 3C: Direct Exposure Beach Area E; Ingestion of Crab from FCA 2/3				
TEQ_{DF}	**4.0**	**11**	0.00098	**15**

Note:
[1] A threshold or minimum dose must be reached for TEQ_{DF} before a carcinogenic effect can occur. Therefore, the potential for cancer to occur as a result of the assumed exposure is estimated using a hazard metric like that described for noncancer hazards. For additional discussion regarding this topic see Integral and Anchor 2013b.
[2] See scenario title for identification of tissue consumed
[3] Two significant figures presented, differences between values presented in the risk assessment tables and those presented here are either a result of the use of a relative bioavailability factor of 1.0, the number of significant figures presented, rounding, or a combination of all three.
FCA – fish collection area
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

The deterministic risk assessment for a subsistence fisher north of I-10 and the aquatic environment is presented in Section 5.2.2.2 of the BHHRA (Integral and Anchor 2013b) and is summarized below. For a subsistence fisher exposure to any of the beaches and the ingestion catfish, clam, or crab from the fishing areas identified have reproductive/developmental noncancer HIs are greater than one and indicate a potential for adverse noncancer effects. The table below provides noncancer HQs for exposure to sediment and fish or shellfish for all scenarios with endpoint-specific HIs greater than one for subsistence fisher exposure scenarios.

North of I-10 and the Aquatic Environment Noncancer Hazards for a Subsistence Fisher

Scenario Timeframe:	Baseline				
Receptor Population:	Subsistence Fisher				
Receptor Age:	Young Child				
Calculation Assumption:	Reasonable Maximum Exposure				
		Noncancer Hazard Quotient			
Chemical[1]	**Primary Target Organ**	**Incidental Ingestion of Sediment**	**Dermal Contact with Sediment**	**Consumption of Fish or Shellfish[2]**	**Exposure Route Total[3]**
Scenario 1A: Direct Exposure Beach Area A; Ingestion of Catfish from FCA 2/3					
TEQ_{DF}	Reproductive/Developmental	0.0012	0.0035	**9.2**	**9.2**
Methylmercury[4]	Reproductive/Developmental	--	--	**2.3**	**2.3**
Reproductive/Developmental Endpoint-Specific Hazard Index					**12**
PCBs	Immune	--	--	**7.4**	**7.4**
Inorganic Mercury[4]	Immune	0.000065	0.00018	--	0.00025
Immune Endpoint-Specific Hazard Index					**7.4**
Scenario 2A: Direct Exposure Beach Area B/C; Ingestion of Catfish from FCA 2/3					
TEQ_{DF}	Reproductive/Developmental	0.017	0.048	**9.2**	**9.3**
Methylmercury[4]	Reproductive/Developmental	--	--	**2.3**	**2.3**
Reproductive/Developmental Endpoint-Specific Hazard Index					**12**
PCBs	Immune	--	--	**7.4**	**7.4**
Inorganic Mercury[4]	Immune	0.00012	0.00035	--	0.00047
Immune Endpoint-Specific Hazard Index					**7.4**

North of I-10 and the Aquatic Environment Noncancer Hazards for a Subsistence Fisher (Continued)

Scenario Timeframe:	Baseline				
Receptor Population:	Subsistence Fisher				
Receptor Age:	Young Child				
Calculation Assumption:	Reasonable Maximum Exposure				
		Noncancer Hazard Quotient			
Chemical[1]	**Primary Target Organ**	**Incidental Ingestion of Sediment**	**Dermal Contact with Sediment**	**Consumption of Fish or Shellfish[2]**	**Exposure Route Total[3]**
Scenario 2B: Direct Exposure Beach Area B/C; Ingestion of Clam from FCA 2					
TEQ_{DF}	Reproductive/Developmental	0.017	0.048	**2.9**	**3.0**
Methylmercury[4]	Reproductive/Developmental	--	--	0.012	0.012
Reproductive/Developmental Endpoint-Specific Hazard Index					**3.0**
Scenario 3A: Direct Exposure Beach Area E; Ingestion of Catfish from FCA 2/3					
TEQ_{DF}	Reproductive/Developmental	**34**	**99**	**9.2**	**140**
Methylmercury[4]	Reproductive/Developmental	--	--	**2.3**	**2.3**
Reproductive/Developmental Endpoint-Specific Hazard Index					**140**
PCBs	Immune	0.13	1.7	7.4	**9.2**
Inorganic Mercury[4]	Immune	0.012	0.035	--	0.047
Immune Endpoint-Specific Hazard Index					**9.3**
Scenario 3B: Direct Exposure Beach Area E; Ingestion of Clam from FCA 2					
TEQ_{DF}	Reproductive/Developmental	**34**	**99**	**2.9**	**140**
Methylmercury[4]	Reproductive/Developmental	--	--	0.012	0.012
Reproductive/Developmental Endpoint-Specific Hazard Index					**140**
PCBs	Immune	0.13	**1.7**	0.26	**2.1**
Inorganic Mercury[4]	Immune	0.12	0.035	--	0.16
Immune Endpoint-Specific Hazard Index					**2.3**
Scenario 3C: Direct Exposure Beach Area E; Ingestion of Crab from FCA 2/3					
TEQ_{DF}	Reproductive/Developmental	**34**	**99**	0.043	**130**
Methylmercury[4]	Reproductive/Developmental	--	--	0.04	0.04
Reproductive/Developmental Endpoint-Specific Hazard Index					**130**
PCBs	Immune	0.13	1.7	0.038	**1.9**
Inorganic Mercury[4]	Immune	0.012	0.035	--	0.047
Immune Endpoint-Specific Hazard Index					**2.0**
Scenario 4A: Direct Exposure Beach Area D; Ingestion of Catfish from FCA 1					
TEQ_{DF}	Reproductive/Developmental	0.0056	0.016	**8.8**	**8.8**
Methylmercury[4]	Reproductive/Developmental	--	--	**3.0**	**3.0**
Reproductive/Developmental Endpoint-Specific Hazard Index					**12**
PCBs	Immune	--	--	**8.2**	**8.2**
Inorganic Mercury[4]	Immune	0.00025	0.00071	--	0.00096
Immune Endpoint-Specific Hazard Index					**8.2**

Note:
[1] All chemicals with primary target organ exposure route totals greater than 1 are included in this table.
[2] See scenario title for identification of tissue consumed
[3] Two significant figures presented, differences between values presented in the risk assessment tables and those presented here are the a result of the use of a relative bioavailability factor of 1.0, the number of significant figures presented, rounding, or a combination of all three.
[4] Consistent with EPA guidance (2010c), 100 percent of mercury detected in tissue was assumed to be methylmercury and 100 percent of mercury detected in soil and sediment was assumed to be inorganic mercury.
FCA – fish collection area
PCB – polychlorinated biphenyls
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

The deterministic risk assessment for a subsistence fisher north of I-10 and the aquatic environment is presented in Section 5.2.2.2 of the BHHRA (Integral and Anchor 2013b) and is summarized below. For a subsistence fisher in Exposure Scenarios 1A, 2A, 3A, 3B, 3C, and 4A (direct exposure to Beach Areas A, B/C, E, and D and the ingestion catfish, clam, or crab from the fishing areas identified), the TEQ_{DF} cancer HIs are greater than one and indicate a potential for cancer. The table below provides TEQ_{DF} cancer HIs for subsistence fisher exposure scenarios that are greater than one.

North of I-10 and the Aquatic Environment Cancer Hazards for a Subsistence Fisher

Scenario Timeframe:	Baseline			
Receptor Population:	Subsistence Fisher			
Receptor Age:	Lifetime			
Calculation Assumption:	Reasonable Maximum Exposure			
	TEQ_{DF} Cancer Hazard Quotient[1]			
Chemical of Concern	**Incidental Ingestion of Sediment**	**Dermal Contact with Sediment**	**Consumption of Fish or Shellfish[2]**	**Total[3]**
Scenario 1A: Direct Exposure Beach Area A; Ingestion of Catfish from FCA 2/3				
TEQ_{DF}	0.00038	0.0011	**2.8**	**2.8**
Scenario 2A: Direct Exposure Beach Area B/C; Ingestion of Catfish from FCA 2/3				
TEQ_{DF}	0.0052	0.015	**2.8**	**2.8**
Scenario 3A: Direct Exposure Beach Area E; Ingestion of Catfish from FCA 2/3				
TEQ_{DF}	**11**	**30**	**2.8**	**44**
Scenario 3B: Direct Exposure Beach Area E; Ingestion of Clam from FCA 2				
TEQ_{DF}	**11**	**30**	0.87	**42**
Scenario 3C: Direct Exposure Beach Area E; Ingestion of Crab from FCA 2/3				
TEQ_{DF}	**11**	**30**	0.013	**41**
Scenario 4A: Direct Exposure Beach Area D; Ingestion of Catfish from FCA 1				
TEQ_{DF}	0.0017	0.0049	2.7	**2.7**

Note:
[1] A threshold or minimum dose must be reached for TEQ_{DF} before a carcinogenic effect can occur. Therefore, the potential for cancer to occur as a result of the assumed exposure is estimated using a hazard metric like that described for noncancer hazards. For additional discussion regarding this topic see Integral and Anchor 2013b.
[2] See scenario title for identification of tissue consumed
[3] Two significant figures presented, differences between values presented in the risk assessment tables and those presented here are the a result of the use of a relative bioavailability factor of 1.0, the number of significant figures presented, rounding, or a combination of all three.
FCA – fish collection area
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

The deterministic risk assessment for a recreational visitor north of I-10 and the aquatic environment is presented in Section 5.2.2.3 of the BHHRA (Integral and Anchor 2013b) and is summarized below. For a recreational visitor in Exposure Scenario 3 (direct exposure to Beach Area E), the reproductive/developmental noncancer HI is greater than one and indicates there is a potential for adverse noncancer effects. The table below provides noncancer HQs for exposure to sediment and soil for all scenarios with endpoint-specific HIs greater than one for recreational fisher exposure scenarios.

North of I-10 and the Aquatic Environment Noncancer Hazards for a Recreational Visitor

Scenario Timeframe:	Baseline					
Receptor Population:	Recreational Visitor					
Receptor Age:	Young Child					
Calculation Assumption:	Reasonable Maximum Exposure					
		Noncancer Hazard Quotient				
Chemical[1]	**Primary Target Organ**	**Incidental Ingestion of Sediment**	**Incidental Ingestion of Soil**	**Dermal Contact with Sediment**	**Dermal Contact with Soil**	**Total[2]**
Scenario 3: Direct Exposure Beach Area E						
TEQ_{DF}	Reproductive/ Developmental	**17**	0.03	**49**	0.0021	**66**
		Reproductive/Developmental Endpoint-Specific Hazard Index				**66**

Note:
[1] All chemicals with primary target organ exposure route totals greater than 1 are included in this table.
[2] Two significant figures presented, differences between values presented in the risk assessment tables and those presented here are the a result of the use of a relative bioavailability factor of 1.0, the number of significant figures presented, rounding, or a combination of all three.
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

The deterministic risk assessment for a recreational visitor north of I-10 and the aquatic environment is presented in Section 5.2.2.3 of the BHHRA (Integral and Anchor 2013b) and is summarized below. For a recreational visitor in Exposure Scenario 3 (direct exposure to Beach Area E), the TEQ_{DF} cancer HI is greater than one and indicates a potential for cancer. The table below provides the TEQ_{DF} cancer HI for the recreational visitor exposure scenario that is greater than one.

North of I-10 and the Aquatic Environment Cancer Hazards for a Recreational Visitor

Scenario Timeframe:	Baseline				
Receptor Population:	Recreational Visitor				
Receptor Age:	Lifetime				
Calculation Assumption:	Reasonable Maximum Exposure				
	TEQ_{DF} Cancer Hazard Quotient[1]				
Chemical of Concern	**Incidental Ingestion of Sediment**	**Incidental Ingestion of Soil**	**Dermal Contact with Sediment**	**Dermal Contact with Soil**	**Total[2]**
Scenario 3: Direct Exposure Beach Area E					
TEQ_{DF}	**5.2**	0.0092	**15**	0.00065	**20**

Note:
[1] A threshold or minimum dose must be reached for TEQ_{DF} before a carcinogenic effect can occur. Therefore, the potential for cancer to occur as a result of the assumed exposure is estimated using a hazard metric like that described for noncancer hazards. For additional discussion regarding this topic see Integral and Anchor 2013b.
[2] Two significant figures presented, differences between values presented in the risk assessment tables and those presented here are the a result of the use of a relative bioavailability factor of 1.0, the number of significant figures presented, rounding, or a combination of all three.
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

Following completion of the deterministic risk assessment, results of which are presented above, refinement analyses were completed if north of I-10 and the aquatic environment exposure scenarios met one or both of the following thresholds:

- An incremental cancer risk greater than one in 10,000 (no scenarios met this)
- A total endpoint-specific noncancer HI greater than 1
- A dioxin cancer HI greater than 1.

Refinement analyses are discussed in Section 5.2.3 of the BHHRA (Integral and Anchor 2013b) and included: 1) an analysis and comparison of background hazards with estimated deterministic hazards for the area, 2) an evaluation of post-TCRA condition hazards, and 3) a probabilistic risk assessment of potential hazards. Only the analysis and comparison of background hazards with estimated deterministic hazards will be presented in this SIP.

The background hazard evaluation is presented in Section 5.2.3.1 of the BHHRA (Integral and Anchor 2013b), the results of which are summarized below. The tables below provide summaries of noncancer and TEQ_{DF} cancer HIs for recreational fisher, subsistence fisher, and recreational visitor exposure scenarios, respectively. Evaluation of background hazards, performed in the BHHRA, indicated the following:

- Sediment
  - Exposure to beach area E resulted in hazards exceeding background
  - Exposure to other beach areas results in hazards consistent with background
- Catfish
  - Ingestion of site catfish results in hazards exceeding background
  - Background hazards contribute to total hazards (e.g., provide almost ½ the total hazards for PCBs and TEQ_{DF})
  - Hazards associated with mercury are likely due to background
- Clams
  - Ingestion of clams from FCA 2 results in hazards exceeding background
  - Ingestion of clams from FCA 1/3 results in hazards slightly higher than background.

Recreational Fisher Summary of Background Hazards

Scenario	Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Hazard Index Total[1]
Noncancer Hazard Index				
A – Direct Exposure to Sediment; Ingestion of Catfish	0.004	0.01	**1**	**1**
B – Direct Exposure to Sediment, Ingestion of Clam	0.004	0.01	0.01	0.03
C – Direct Exposure to Sediment; Ingestion of Crab	0.004	0.01	0.01	0.03
TEQ_{DF} Cancer Hazard Index				
A – Direct Exposure to Sediment; Ingestion of Catfish	0.00018	0.0005	0.1	0.1
B – Direct Exposure to Sediment, Ingestion of Clam	0.00018	0.0005	0.002	0.003
C – Direct Exposure to Sediment; Ingestion of Crab	0.00018	0.0005	0.0006	0.001

Note:
Differences between values presented in the risk assessment tables and those presented here are a result of the use of a relative bioavailability factor of 1.0.
[1] Calculations based on reasonable maximum exposure.
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

Subsistence Fisher Summary of Background Hazards

Scenario	Incidental Ingestion of Sediment	Dermal Contact with Sediment	Fish or Shellfish Ingestion	Hazard Index Total[1]
Noncancer Hazard Index				
A – Direct Exposure to Sediment; Ingestion of Catfish	0.01	0.04	**10**	**10**
B – Direct Exposure to Sediment; Ingestion of Clam	0.01	0.04	0.2	0.2
C – Direct Exposure to Sediment; Ingestion of Crab	0.01	0.04	0.1	0.2
TEQ_{DF} Cancer Hazard Index				
A – Direct Exposure to Sediment; Ingestion of Catfish	0.0004	0.001	**1**	**1**
B – Direct Exposure to Sediment; Ingestion of Clam	0.0004	0.001	0.02	0.02
C – Direct Exposure to Sediment; Ingestion of Crab	0.0004	0.001	0.008	0.01

Note:
Differences between values presented in the risk assessment tables and those presented here are a result of the use of a relative bioavailability factor of 1.0.
[1] Calculations based on reasonable maximum exposure.
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

Recreational Visitor Summary of Background Hazards

Scenario	Incidental Ingestion of Sediment	Incidental Ingestion of Soil	Dermal Contact with Sediment	Dermal Contact with Soil	Hazard Index Total[1]
Noncancer Hazard Index					
Direct Exposure to Sediment and Soil	0.004	0.02	0.02	0.003	0.05
TEQ_{DF} Cancer Hazard Index					
Direct Exposure to Sediment and Soil	0.0002	0.004	0.0007	0.0002	0.005

Note:
Differences between values presented in the risk assessment tables and those presented here are a result of the use of a relative bioavailability factor of 1.0.
[1] Calculations based on reasonable maximum exposure.
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

The human health risk assessment summary and conclusions for the area south of I-10 is presented in Section 6.2.4 of the BHHRA (Integral and Anchor 2013b) and is summarized below. For the area south of I-10, the future construction worker TEQ_{DF} noncancer and cancer HIs are greater than one for exposure areas DS-1, DS-2, and DS-4. The tables below provide endpoint-specific HIs and cumulative noncancer HIs for future construction worker exposure scenarios that have a noncancer HI greater than one and TEQ_{DF} cancer HIs for future construction worker exposure scenarios that have a TEQ_{DF} cancer HI greater than one.

South of I-10 Noncancer Hazards for a Future Construction Worker

Scenario Timeframe:	Baseline			
Receptor Population:	Construction Worker			
Receptor Age:	Adult			
Calculation Assumption:	Reasonable Maximum Exposure			
		Noncancer Hazard Quotient		
Chemical[1]	**Primary Target Organ**	**Incidental Ingestion of Soil**	**Dermal Contact with Soil**	**Total[2]**
Scenario DS-1: Direct Exposure to Surface and Subsurface Soils				
TEQ_{DF}	Reproductive/Developmental	**9.6**	0.49	**10**
		Reproductive/Developmental Endpoint-Specific Hazard Index		**10**
Scenario DS-2: Direct Exposure to Surface and Subsurface Soils				
TEQ_{DF}	Reproductive/Developmental	**44**	**2.2**	**46**
		Reproductive/Developmental Endpoint-Specific Hazard Index		**46**
Scenario DS-4: Direct Exposure to Surface and Subsurface Soils				
TEQ_{DF}	Reproductive/Developmental	**32**	**1.6**	**34**
		Reproductive/Developmental Endpoint-Specific Hazard Index		**34**
Scenario DS-5: Direct Exposure to Surface and Subsurface Soils				
TEQ_{DF}	Reproductive/Developmental	**2.2**	**0.11**	**2.3**
		Reproductive/Developmental Endpoint-Specific Hazard Index		**2.3**

Note:
[1] All chemicals with primary target organ exposure route totals greater than 1 are included in this table.
[2] Two significant figures presented, differences between values presented in the risk assessment tables and those presented here are the a result of the use of a relative bioavailability factor of 1.0, the number of significant figures presented, rounding, or a combination of all three.
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

South of I-10 Cancer Hazards for a Future Construction Worker

Scenario Timeframe:	Baseline		
Receptor Population:	Construction Worker		
Receptor Age:	Lifetime		
Calculation Assumption:	Reasonable Maximum Exposure		
	TEQ_{DF} Cancer Hazard Quotient[1]		
Chemical of Concern	**Incidental Ingestion of Soil**	**Dermal Contact with Soil**	**Total[2]**
Scenario DS-1: Direct Exposure to Surface and Subsurface Soils			
TEQ_{DF}	**3.0**	0.15	**3.2**
Scenario DS-2: Direct Exposure to Surface and Subsurface Soils			
TEQ_{DF}	**13**	0.67	**14**
Scenario DS-4: Direct Exposure to Surface and Subsurface Soils			
TEQ_{DF}	**9.6**	0.48	**10**

Note:
[1] A threshold or minimum dose must be reached for TEQ_{DF} before a carcinogenic effect can occur. Therefore, the potential for cancer to occur as a result of the assumed exposure is estimated using a hazard metric like that described for noncancer hazards. For additional discussion regarding this topic see Integral and Anchor 2013b.
[2] Two significant figures presented, differences between values presented in the risk assessment tables and those presented here are the a result of the use of a relative bioavailability factor of 1.0, the number of significant figures presented, rounding, or a combination of all three.
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

The BHHRA identifies the following as sources contributing to risk assessment uncertainty in Sections 5.2.4 and 6.2.3:

- Data collection, analysis, and treatment (e.g., elevated detection limits for PCBs as Aroclors, analysis of 43 PCB congeners rather than the complete set of 209)

- Calculation of dioxin and furan TEQs (e.g., use of ½ the detection limit for nondetect congeners)
- Exposure assessment assumptions (e.g., the lack of quantification of minor pathways, age assumptions, fish and shellfish consumption rates)
- Toxicity criteria (e.g., dioxins and furans, PCBs).

However, states that “the parameters used for evaluating potential exposures and estimating risks and hazards relied on multiple conservative assumptions, which enhance the likelihood that potential assumed exposures and estimated risks are overestimated” (Integral and Anchor 2013b).

2.7.2 *Summary of Ecological Risk Assessment*

A screening level ecological risk assessment (SLERA) for the site, not addressing the southern impoundment, was completed in 2010. The initial SLERA is included as Appendix B to the RI/FS Work Plan (Anchor and Integral 2010). Following completion of the SLERA, a BERA for the site, not addressing the southern impoundment, was completed (Integral 2013). A SLERA for the southern impoundment was completed concurrently with the site BERA and is included as Appendix E to the BERA (Integral 2013). A BERA for the southern impoundment was subsequently completed and is included as Appendix D to the RI Report (Integral and Anchor 2013a).

Identification of Chemicals of Potential Ecological Concern

The BERA for the area north of I-10 and aquatic environments identified chemicals of potential ecological concern (COPECs). Tables 19 and 20 present the COPEC screening. Chemicals in sediment with a detection frequency of at least 5 percent in the RI dataset that were either 1) present in at least one sample at a concentration greater than sediment screening concentrations protective of benthic invertebrate communities or 2) have no screening value protective of benthic invertebrate communities and were not correlated with dioxins and furans, are considered COPECs for benthic macroinvertebrate communities (Integral 2013). If a chemical was detected in greater than 5 percent of sediment samples in the RI dataset, and is thought to be bioaccumulative (TCEQ 2006), it was considered to be a COPEC was evaluated for fish and wildlife (Integral 2013).

Exposure Assessment

The site is located in a low gradient, tidal estuary near the confluence of the San Jacinto River and the Houston Ship Channel, as discussed above in Section 2.5 of this SIP. Habitats include upland, aquatic, and riparian.

There are no site-specific data describing wildlife uses of the upland portions of the site. Based on local wildlife lists and the types of habitat and land uses, it is reasonable to expect a suite of generalist terrestrial species that are not highly specialized in their habitat requirements and are adapted to moderate levels of disturbance. The reptiles and amphibians that could occur in the vicinity of the site include snakes, alligators, and turtles. Avian taxa using upland habitats may include sparrows and other generalist passerines, starlings, pigeons and doves, corvids, and killdeer. Mammals expected in a semi-urban environment like the site include small mammals (rodents), skunks, raccoons, coyotes, and opossums. Upland habitats could support mammals, such as marsh rice rats and deer that could migrate to the islands close to mainland areas, as well as passerines that could use the vegetated uplands for nesting and foraging, and shoreline birds such as sandpipers and herons that could wade and forage in the shallow areas adjacent to the islands.

The tidal portions of the San Jacinto River and upper Galveston Bay provide rearing, spawning, and adult habitat for a variety of marine and estuarine fish and invertebrate species. Species known to occur in the vicinity of the site include clams and oysters, blue crab (*Callinectes sapidus*), black drum (*Pagonius cromis*), southern flounder (*Paralichthys lethostigma*), hardhead (*Ariopsis afelis*), blue catfish (*Ictalurus furcatus*), spotted sea trout (*Cynoscion nebulosis*), and grass shrimp (*Paleomonetes pugio*) (Gardiner et al. 2008; Usenko et al. 2009).

Aquatic birds and semiaquatic mammals that are found in the vicinity of the site include ducks, shorebirds, wading birds (herons and egrets), diving piscivores, and various others. There are a number of migratory bird species known to winter in the vicinity of the site. They include belted kingfisher (*Megaceryle alcyon*), red breasted merganser (*Mergus serrator*), greater yellowlegs (*Tringa melanoleuca*), western sandpiper (*Calidris mauri*), and dabbling ducks including gadwall (*Anas strepera*) and teal. Herons and closely related birds that use wetland and estuarine habitats and that may be present in the site vicinity include the green (*Butorides virescens*), tri-colored (*Egretta tricolor*), and little blue (*E. cerulea*) herons, and also the black-crowned (*Nycticorax nycticorax*) and yellow-crowned (*N. violacea*) night-herons. Raptors, rails, pelicans, gulls, ducks, and sandpipers are also among the aquatic-dependent and aquatic-associated bird species that use the aquatic habitat that is present in the vicinity of the site. Sandpipers, egrets, and herons are wading birds that forage along shallow intertidal areas for benthic macroinvertebrates and small fish. Piscivorous bird species that may forage in the open waters of the river include cormorants, osprey, and pelicans. Omnivores including gulls and ducks may forage at the river's edge as well as in the water column. Mammals using both aquatic and wetland habitats that could occur in the vicinity of the site include the marsh rice rat, muskrats, nutria, and raccoon.

Endangered and Threatened Species

Wildlife that are state-listed as threatened and endangered and have the potential to be found in the general vicinity of the site are:

- Timber rattlesnake
- Smooth green snake
- Alligator snapping turtle
- White-faced ibis

- Brown pelican
- Rafinesque's big-eared bat.

In addition to these listed species, the American bald eagle, protected under the federal Bald and Golden Eagle Protection Act and listed as threatened by the State of Texas, may be found in the vicinity of the site.

Ecological Receptors and Receptor Surrogates

Ecological receptor surrogates were selected to be representative of the trophic and ecological relationships known or expected at the site. In selecting receptor surrogates, the following criteria were considered:

- The receptor is or could potentially be present at the site.
- The receptor is representative of one or more feeding guilds.
- The receptor is known to be either sensitive or potentially highly exposed to COPECs at the site.
- Life history information is available in the literature or is available for a similar species that can be used to inform life history parameters for the receptor.

Tables 23 and 24 provide receptors used in the north of I-10 and south of I-10 BERAs, respectively. Tables 25 and 26 provide assessment endpoints, lines of evidence, and measurement of exposure for the area north of I-10 and aquatic environment, and the area south of I-10, respectively.

Ecological Risk Characterization

The table below presents a summary of baseline ecological risks identified in the BERA (Integral 2013) for the area north of I-10 and aquatic environment.

Summary of Baseline Ecological Risks for the Area North of I-10 and Aquatic Environment

Receptor of Concern	Feeding Guild	Chemical of Concern	Baseline Risk Identified[1]
Benthic Macroinvertebrates			
Mollusks	Filter feeders	2,3,7,8-TCDD	Reproductive risks to mollusks (primarily in the area which surrounds the waste impoundments)
Individual mollusks	Filter feeders	2,3,7,8-TCDD	Low risks of reproductive effects (sediments adjacent to the upland sand separation area)
Birds			
Spotted sandpiper	Invertivore (probing)	Dioxins and furans	Moderate risks to individual birds, low risk to populations
Killdeer	Invertivore (terrestrial)	Dioxins and furans	Moderate risks to individual birds, low risk to populations
Killdeer	Invertivore (terrestrial)	Zinc	Low to negligible risk to populations
Mammals			
Marsh rice rat	Omnivore	$TEQ_{DF,M}$	Risk to individual small mammals with home ranges that include areas adjacent to the impoundments, low to negligible risk to populations

Note:
[1] Risk to individuals of characterized as negligible are not included in this table.
2,3,7,8-TCDD – 2,3,7,8-tetrachlorodibenzo-p-dioxin
Dioxins – polychlorinated dibenzo-p-dioxins
Furans – polychlorinated dibenzofurans
$TEQ_{DF,M}$ – toxicity equivalent quotient for 2,3,7,8-tetrachlorodibenzo-p-dioxin calculated using toxicity equivalent factors for mammals

The table below presents a summary of baseline ecological risks identified in the BERA (Integral and Anchor 2013a) for the area south of I-10.

Summary of Baseline Ecological Risks for the Area South of I-10

Receptor of Concern	Feeding Guild	Chemical of Concern	Baseline Risk Identified[1]
Birds			
Terrestrial birds	--	Cadmium Chromium Copper	Low to negligible risks to the assessment endpoint of stable or increasing populations
Killdeer	Invertivore (terrestrial)	Lead Zinc	Risks to individual birds are present and population-level risks may be present

Note:
[1] Risk to individuals of characterized as negligible are not included in this table.

2.7.3 *Basis for Action*

The response action preferred in this SIP is necessary to protect the public health or welfare and the environment from actual or threatened releases of hazardous substances, as defined by NCP §300.5, into the environment.

2.8 REMEDIAL ACTION OBJECTIVES

RAOs describe what the proposed site cleanup is expected to accomplish. According to the NCP, 40 CFR §300.430(a)(1)(i), the "national goal of the remedy selection process is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste." Based on information relating to types of contaminants, environmental media of concern, and potential exposure pathways, site specific RAOs were developed.

RAO 1: Eliminate loading of dioxins and furans from the former waste impoundments north and south of I-10, to sediments of the San Jacinto River.

RAO 2: Reduce human exposure to dioxins and furans from consumption of fish by remediating sediments affected by paper mill wastes to appropriate cleanup levels.

RAO 3: Reduce human exposure to dioxins and furans from direct contact with intertidal sediment by remediating sediments affected by paper mill wastes to appropriate levels.

RAO 4: Reduce human exposure to paper mill waste-derived dioxins and furans from direct contact with upland soils to appropriate cleanup levels.

RAO 5: Reduce exposures of benthic invertebrates, birds, and mammals to paper mill waste-derived dioxins and furans by remediating sediment affected by paper mill wastes to appropriate cleanup levels.

The RAOs developed consider the current and reasonably anticipated future land use including the use for industrial applications and by recreational fishers. While the BHHRA considered subsistence fisher populations, none have been identified at the site and therefore this receptor is not considered to be consistent with the current or future land use. Reducing exposure of human and ecological receptors of concern to dioxins and furans will mitigate site baseline risks identified in the BHHRA and BERAs and discussed in Section 2.7. The quantitative cleanup levels that need to be met to achieve the RAOs are presented in the table below.

Human Health Chemicals of Concern and Cleanup Levels

Chemical of Concern	Media	Cleanup Level	Basis for Cleanup Level
TEQ_{DF}	Sediment	200 ng/kg[1]	Child Recreational Visitor[2], Calculated Risk Based Noncancer Endpoint[3]
TEQ_{DF}	Soil	240 ng/kg[1]	Construction Worker, Calculated Risk Based Noncancer Endpoint[3]
Polychlorinated Biphenyls	Sediment	2 mg/kg[4]	Recreational Fisher, Calculated Risk Based Noncancer Hazard Index[3]

Note:
[1] Assumptions and derivations of cleanup levels are presented in Anchor 2016.
[2] Development of a cleanup level based on recreational fisher exposure would also be appropriate and considered, however the cleanup level based on exposure to a recreational visitor is more conservative and will therefore be protective of recreational fishers.
[3] Calculations based on a relative bioavailability adjustment of 1.
[4] Assumptions and derivations of cleanup levels are presented in Integral and Anchor 2013a
ng/kg – nanograms per kilogram
TEQ_{DF} – 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalent quotient

Ecological Chemicals of Concern and Cleanup Levels

Chemical of Concern	Media	Cleanup Level	Area Cleanup Level is Applicable To
2,3,7,8-TCDD	Sediment	991 ng/kg	North of I-10 and Aquatic Environment
2,3,7,8-TCDD	Soil	3,150 ng/kg	North of I-10 and Aquatic Environment
Zinc	Soil	4,020 mg/kg	North of I-10 and Aquatic Environment
Cadmium	Soil	2.02 mg/kg	Area South of I-10
Chromium	Soil	35.4 mg/kg	Area South of I-10
Copper	Soil	69.2 mg/kg	Area South of I-10
Lead	Soil	85.5 mg/kg	Area South of I-10
Zinc	Soil	4,200 mg/kg	Area South of I-10

Note:
Dioxins – polychlorinated dibenzo-p-dioxins
Furans – polychlorinated dibenzofurans
mg/kg – milligrams per kilogram
ng/kg – nanograms per kilogram
$TEQ_{DF,M}$ – toxicity equivalent quotient for 2,3,7,8-tetrachlorodibenzo-p-dioxin calculated using toxicity equivalent factors for mammals

2.9 DESCRIPTION OF ALTERNATIVES

The alternatives developed and presented in the FS (EPA 2016) are presented below. Each alternative presents a description of remedy components, common elements and distinguishing features, and expected outcomes of each alternative. Alternatives that address the area north of I-10 and aquatic environment include the letter “N” in the title (e.g., 1N, 2N) and alternatives that address the area south of I-10 include the letter “S” in the title (e.g., 1S).

2.9.1 *Alternative 1N – Armored Cap and Ongoing Operations, Monitoring, and Maintenance (No Further Action)*

As described in Section 2.2.5, the TCRA included capping the northern impoundments, selected stabilization of near surface soils in the western cell, installing a security fence, and posting warning signs. Under this alternative, the controls installed as part of the TCRA and as a result of the TCRA reassessment would remain in place and no additional remedial action would be implemented. This alternative includes ongoing operations, monitoring, and maintenance of the armored cap, which includes inspection and periodic maintenance (see Section 2.2.5 for details), and EPA 5-year reviews as required under the NCP in 40 CFR 300.430 (f)(iv)(2). The estimated cost of this alternative is $9.5 million which includes the cost of the TCRA armored cap design and construction (Appendix A).

2.9.2 *Alternative 2N – Armored Cap, Institutional Controls, and Monitored Natural Recovery*

This alternative includes all of the elements discussed under Alternative 1N, plus ICs and MNR. Under this remedial alternative, the following ICs would be implemented:

- Restrictions on dredging and anchoring would be established to protect the integrity of the armored cap and to limit potential disturbance and resuspension of buried sediment near the upland sand separation area where one location exists with TEQ_{DF} concentrations exceeding the sediment cleanup goal.

- Public notices and signage around the perimeter of the TCRA site would be maintained or provided, as appropriate.

- A periodic sampling and analytical program would also be implemented to monitor the progress of natural recovery.

The estimated cost for this alternative is $10.3 million (Appendix A).

2.9.3 *Alternative 3N – Permanent Cap, Institutional Controls, and Monitored Natural Recovery*

This alternative includes the actions described under Alternative 2N plus additional enhancements to the TCRA armored cap to create a permanent cap. This alternative will increase the long-term stability of the armored cap consistent with permanent isolation of impacted materials. Cost estimates for this alternative also include additional measures to protect the permanent cap from potential vessel traffic in the form of a protective perimeter barrier and could include construction of a 5-foot high submerged rock berm outside the perimeter of the permanent cap, in areas where vessels could potentially impact the cap.

Enhancements to the armored cap would involve flattening the slopes of the existing cap by adding additional armor rock material to enhance the effectiveness and permanence by increasing the degree of safety. The permanent cap would include 1.5 for sizing the armor stone, flattening submerged slopes from 2 horizontal to 1 vertical (2H:1V) to 3H:1V, and flattening the slopes in the surf zone from 3H:1V to 5 horizontal to 1 vertical (5H:1V). The permanent cap would use larger rock sized for the “No Displacement” design scenario, which is more conservative than the “Minor Displacement” scenario used in the armored cap’s design. Upon completion, the Permanent Cap will be constructed to a standard that exceeds EPA and USACE design guidance, and meets or exceeds the recommended enhancements suggested by USACE in their 2013 evaluation. ICs would be implemented to place restrictions on dredging and anchoring to protect the integrity of the armored cap and to limit potential disturbance and resuspension of buried sediment near the upland sand separation area where one location exists with TEQDF concentrations exceeding the sediment cleanup goal.

Based on the production rates that were realized during TCRA construction, the duration of construction for this alternative is estimated to be 2 months. The cost of this alternative is estimated to be $12.5 million (Appendix A).

2.9.4 *Alternative 4N – Partial Solidification/Stabilization, Permanent Cap Institutional Controls, and Monitored Natural Recovery*

This remedial alternative provides for solidification and stabilization (S/S) of the most highly contaminated material. A dioxin furan value that exceeds 13,000 ng/kg TEQ_{DF} was used to define the most highly contaminated material. The extent of the area for partial S/S was defined, based on sediment and soil chemistry results presented in the RI Report, as the western cell and a portion of the eastern cell that is currently covered by the TCRA armored cap. The maximum depth of S/S in the western cell would be to approximately 10-feet below the current base of the armored cap and on average approximately 5-feet below the current base of the armored cap in the eastern cell and northwestern area.

S/S treatment could be accomplished using large-diameter augers or conventional excavators. Before treating the sediment, the affected portions of the armored cap armor rock would need to be removed and stockpiled for reuse, if possible, or washed to remove adhering sediment and disposed in an appropriate upland facility. The geotextile and geomembrane would need to be removed and disposed of as contaminated debris. S/S reagents, such as Portland cement, would be delivered to the project work area, stockpiled, and mixed with sediment, as needed, to treat the sediment in situ. Submerged areas to be stabilized would need to be isolated from the surface water with sheet piling and mostly dewatered prior to mixing with treatment reagents using conventional or long reach excavators in a fashion similar to the S/S work completed during the TCRA. For FS purposes, a sheet pile enclosure with a top elevation 2 feet above typical mean higher high water, or 3.5 feet North American Vertical Datum of 1988, has been assumed. Following completion of the S/S operation in submerged areas the sheet pile enclosure would be removed.

Finally, the permanent cap, as described in Alternative 3N, would be constructed, including replacement of the armor rock layer geomembrane and geotextile over the S/S footprint, and the measures described under Alternative 3N to protect the permanent cap from vessel traffic would be implemented. ICs would be implemented to place restrictions on dredging and anchoring to protect the integrity of the armored cap and to limit potential disturbance and resuspension of buried sediment near the upland sand separation area where one location exists with TEQDF concentrations exceeding the sediment cleanup goal.

The estimated footprint of this alternative is approximately 2.6 acres in the western cell and 1.0 acre of submerged sediment spanning the eastern cell and the northwestern area. Based on the horizontal and vertical limits identified for this alternative, a total of approximately 52,000 cy of soil and sediment would be treated.

Using production rates similar to that achieved during the TCRA, this alternative has an estimated construction duration of 17 months. As with Alternative 3N, access to the work area from the uplands will be required and could be a challenge, and an off-site staging area would be necessary to manage the materials generated during removal of the armored cap, and to stockpile and load the new armor rock materials to be placed for construction of the permanent cap. The cost of this alternative is estimated to be $23.2 million (Appendix A).

2.9.5 *Alternative 5N – Partial Removal, Permanent Cap, Institutional Controls, and Monitored Natural Recovery*

This remedial alternative provides for removal and off-site disposal of the most highly contaminated material. A dioxin and furan value that exceeds 13,000 ng/kg TEQ_{DF} was used to define the most highly contaminated material. The lateral and vertical extent and volume of sediment removed under this alternative is the same as the sediment to be treated as described in the previous section for Alternative 4N. Construction of a permanent cap, ICs, and MNR, as described in Alternative 3N, are also included in this remedial alternative.

To mitigate potential water quality issues, submerged areas would need to be isolated using berms, sheet piles, and/or turbidity barrier/silt curtains prior to excavating sediment. Upland areas would not need to be isolated with sheet piling, but the excavation would require continuous dewatering and may need to be timed to try to avoid high water and times of year when storms are most likely.

Excavated sediment would be dewatered and potentially treated to eliminate free liquids prior to transporting it for disposal. Effluent from excavated sediment dewatering would need to be handled appropriately, potentially including treatment prior to disposal. Following completion of the excavation, the work area would be backfilled to replace the excavated sediment and then the permanent cap would be constructed, including replacing the armor rock layer above the excavation footprint and the geomembrane and geotextile layers. ICs would be implemented to place restrictions on dredging and anchoring to protect the integrity of the armored cap and to limit potential disturbance and resuspension of buried sediment near the upland sand separation area where one location exists with TEQDF concentrations exceeding the sediment cleanup goal.

The construction duration for this alternative is estimated to be 13 months. The cost of this alternative is estimated to be $38.1 million (Appendix A).

2.9.6 *Alternative 5aN - Partial Removal of Materials Exceeding Cleanup Levels, Permanent Cap, Institutional Controls, and Monitored Natural Recovery*

For this removal alternative, the cleanup goal for a recreational visitor (200 ng/kg TEQ_{DF}) was considered for the area within the armored cap which is either above the water or where the water depth is 10 feet or less. As an additional criterion, locations exceeding 13,000 ng/kg TEQ_{DF} are also included regardless of water depth; however, all samples exceeding 13,000 ng/kg TEQ_{DF} are located in areas where the water depth is 10 feet or less.

As with Alternatives 4N and 5N, the existing armored cap (consisting of cap rock, geomembrane, and geotextile) which currently isolates and contains impacted material would need to be removed prior to beginning excavation work.

This alternative also includes an engineered barrier to manage water quality during construction. In shallow water areas (water depths up to approximately 3 feet), this barrier would be constructed as an earthen berm, extending to an elevation at least

2 feet above the high water elevation in consideration of wind-generated waves and vessel wakes. The berm would be limited to a total height of 4 to 5 feet above the existing mudline for constructability reasons: as the berm height increases, the base width increases and it can be challenging to efficiently construct taller berms because they become wider at their base than the reach of a typical excavator. In areas with water depths deeper than about 3 feet, the berm would transition into a sheet pile barrier around the work area.

Work would be conducted in the wet. Excavated sediment would be offloaded, dewatered and stabilized at a dedicated offloading location, as necessary, to eliminate free liquids for transportation and disposal. Following removal of impacted sediment, the area from which sediments are removed would be covered with a residuals management layer of clean cover material. In the deeper water areas of the TCRA Site where removal is not conducted, the existing armored cap would be maintained. ICs would be implemented to place restrictions on dredging and anchoring to protect the integrity of the armored cap and to limit potential disturbance and resuspension of buried sediment near the upland sand separation area where one location exists with TEQDF concentrations exceeding the sediment cleanup goal.

This alternative entails removal of approximately 137,600 cy of sediment. Alternative 5aN is estimated to have a construction duration of 19 months. The cost of this alternative is estimated to be $77.9 million (Appendix A).

2.9.7 *Alternative 6N - Full Removal of Materials Exceeding Cleanup Levels, Institutional Controls, and Monitored Natural Recovery*

For the full removal alternative, the recreational visitor exposure scenario was considered for area north of I-10. The cleanup goal for protection of the recreational visitor is a TEQ_{DF} concentration of 200 ng/kg.

The full removal alternative will utilize Best Management Practices (BMPs) to reduce the re-suspension of sediment and release to the river. The removal will be completed in stages or sections as appropriate to limit the exposure of the uncovered sections of the waste pits to potential storms. The design approach for removal in stages will be determined in the Remedial Design. Raised berms, sheet piles, and silt curtains in addition to dewatering and removal in the dry to the extent practicable will be used to reduce the re-suspension and spreading to the removed material. The berms would be armored on the external site with armor material removed from the areas that have geotextile present. Residual concentrations of contaminants following excavation and dredging will be covered by at least two layers of clean fill to limit intermixing of residual material with the clean fill. As with the partial removal alternatives, cap rock, geomembrane and geotextile from the existing armored cap, which currently isolates and contains impacted material, would be removed prior to beginning excavation. Dredging of submerged sediments will include isolation of the work area with a turbidity barrier/silt curtain and raised berms/sheet piles where practicable. Excavated sediment would be dewatered and stabilized at the offloading location, as necessary, to eliminate free liquids for transportation and disposal. Some operations, such as water treatment, may be barge mounted. Following removal of impacted sediment, the area from which sediments are removed will be covered with at least two residuals management layers of clean sediment to reduce intermixing. Institutional Controls (ICs) will be used to prevent disturbance of the dredge residuals below the cover layers in the remediated areas.

This alternative entails removal of approximately 200,100 cy of sediment from the TCRA footprint and the area near the upland sand separation area, which would require a relatively large offloading and sediment processing facility to efficiently accomplish the work, which would require barge unloading, sediment re-handling, dewatering, stockpiling, transloading, and shipping to the off-site landfill facility. Additional activities would include management and disposal of dewatering effluent, including treatment if necessary.

Alternative 6N is estimated to have a construction duration of 16 months. The cost of this alternative is approximately $99.2 million (Appendix A).

2.9.8 *Alternative 1S – No Further Action*

Under this remedial alternative for the area of investigation south of I-10, impacted soil would remain in place and no steps would be taken to alert future landowners or construction workers of the presence, at depth, of TEQ_{DF} concentrations exceeding cleanup goals.

The estimated cost for this alternative, which includes future EPA 5-year review costs, is $140,000. These EPA 5-year review costs are also included in cost estimates for the other alternatives.

2.9.9 *Alternative 2S – ICs*

This alternative would apply to locations in the area south of I-10 where the average TEQ_{DF} concentration in the upper 10 feet of soil below grade exceeds the cleanup goal for the future construction worker (240 ng/kg TEQ_{DF}). TEQ_{DF} concentrations in the upper 10 feet of soil exceed the cleanup goal at four locations (SJSB012, SJSB019, SJSB023, and SJSB025).

Under this remedial alternative, the following ICs would be implemented:

- Deed restrictions would be applied parcels in which the depth-weighted average TEQ_{DF} concentrations in upper 10 feet of subsurface soil exceed the soil cleanup goal for the future construction worker.

- Notices would be attached to deeds of affected properties to alert potential future purchasers of the presence of waste and soil with $TEQ_{DF,M}$ concentrations exceeding the soil cleanup goal.

The estimated cost for this remedial alternative is $270,000 (Appendix A).

2.9.10 *Alternative 3S – Enhanced ICs*

This remedial alternative would incorporate the ICs identified in Alternative 2S and add physical features to enhance the effectiveness of the ICs. The physical features would include bollards to define the areal extent of the remedial action areas at the surface and a marker layer that would alert workers digging in the area that deeper soil may be impacted.

Implementation of this remedial alternative may include the following steps:

- Removing up to 2 feet of surface soil
- Temporarily stockpiling the soil on-site
- Placing the marker layer (such as a geogrid or similar durable and readily visible material) at the bottom of the excavation
- Returning the soil to the excavation and re-establishing vegetative cover
- Placing bollards at the corners of the remedial action areas.

The duration of construction for this remedial alternative is estimated to be 1 month. The estimated cost for this remedial alternative is $670,000 (Appendix A).

2.9.11 *Alternative 4S – Removal and Off-site Disposal*

This remedial alternative involves excavation and replacement of soil in the three remedial action areas. Soil would be removed within these areas to a depth of 10 feet below grade. Implementation of this remedial alternative would require dewatering (groundwater lowering) to allow excavation of impacted soil in relatively dry conditions and may need to be timed to try to avoid high water and periods when storms are most likely. Excavated soil would be further dewatered, as necessary, and potentially treated to eliminate free liquids prior to transporting it for disposal. Effluent from excavation and subsequent dewatering would need to be handled appropriately, potentially including treatment prior to disposal. Excavated soil would be disposed of at an existing permitted landfill, the excavation would be backfilled with imported soil, and vegetation would be re-established.

An existing building (an elevated frame structure) and a concrete slab would need to be demolished and removed prior to excavating the underlying soil. These features would be replaced, if necessary.

The removal volume (50,000 cy) was calculated assuming a conservative excavation side slope of 2 horizontal to 1 vertical. Transportation and disposal costs were estimated assuming that all of the excavated material would be transported to a licensed landfill for disposal. During remedial design, potential cost savings associated with segregating clean soil and using it as backfill may be explored.

The duration of construction for this remedial alternative is estimated to be 7 months. The estimated cost for this remedial alternative is $9.9 million (Appendix A).

2.10 COMPARATIVE ANALYSIS OF ALTERNATIVES

Nine criteria are used to evaluate the different remedial alternatives individually and against each other in order to select a remedy. The nine evaluation criteria are (1) overall protection of human health and the environment; (2) compliance with ARARs; (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, or volume through treatment; (5) short-term effectiveness; (6) implementability; (7) cost; (8) state/support agency acceptance; and (9) community acceptance. The nine evaluation criteria are discussed below. Analysis for alternatives for the area north of I-10 and aquatic environment and alternatives for the area south of I-10 will be discussed separately because one alternative for each area must be selected.

2.10.1 *Threshold Criteria*

Of the nine criteria used to evaluate remedial alternatives, discussed above, the first two criteria are considered threshold criteria and must be met for an alternative to be a viable option.

Overall Protection of Human Health and the Environment

This criterion addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls. This criterion is considered a threshold and must be met by the Preferred Remedy.

Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA, 42 U.S. Code § 9621(d), and 40 CFR § 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations that are collectively referred to as ARARs, unless such ARARs are waived under CERCLA Section 121(d)(4), 42 U.S. Code § 9621(d)(4). This criterion is considered a threshold and must be met by the Preferred Remedy.

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that while not “applicable” to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be relevant and appropriate.

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statues or provides a basis for invoking a waiver.

North of I-10 and Aquatic Environment

All of the remedial alternatives evaluated in this FS for the area north of I-10 satisfy the threshold criteria of protecting human health and the environment and addressing ARARs. The surface-weighted average TEQ_{DF} concentration in surface sediments (which are associated with a variety of dioxin sources in addition to paper mill waste that was placed in the impoundments) was reduced by more than 80 percent by the implementation of the TCRA. Based on the fate and transport modeling, this reduction in sediment concentration translates to improvements in water quality at the site, even though there are ongoing inputs of dioxins and furans from sources other than the impoundments. The current (post-TCRA) condition is such that there is little potential for exposure to TEQ_{DF} concentrations unless there is a future release due to an extreme storm or hurricane, or a future release due to the impacts of a barge strike.

South of I-10

Other than Alternative 1S, the remedial alternatives for the area south of I-10 considered in this FS Report meet both of the threshold criteria: protectiveness and compliance with ARARs. The potentially affected receptor (future construction worker) would be protected from exposure to soil with elevated TEQ_{DF} concentrations by warnings and restrictions (Alternatives 2S and 3S) or removal of impacted soil (Alternative 4S).

With reasonable care, any of the remedial alternatives could be implemented in compliance with ARARs. Soil that is removed (Alternative 4S) would be transported in compliance with TxDOT standards and permanently managed in a permitted landfill cleared by the EPA's regional off-site rule contact.

2.10.2 *Long-Term Effectiveness and Permanence*

Long-term effectiveness and permanence refers to the expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.

North of I-10 and Aquatic Environment

The long-term effectiveness evaluation of MNR-based remedies projects that the surface weighted average concentration of TEQ_{DF} will decrease by approximately a factor of two in a 10- to 15-year time frame due to natural sedimentation processes in the river. Construction of the armored cap reduced surface weighted average concentration TEQ_{DF} by approximately 80 percent, and natural recovery will continue to reduce concentrations because of the ongoing input of sediment with low TEQ_{DF} concentrations from upstream sources.

Alternative 1N does not include ICs and MNR is not assessed over time, so the long-term effectiveness of this alternative ranks lower than all of the other alternatives. The existing armored cap is not further enhanced in Alternatives 1N or 2N compared to Alternative 3N, which could increase the need for future long-term monitoring and maintenance under Alternatives 1N and 2N.

The evaluations performed to address the permanence of the existing repaired TCRA cap with the proposed modifications outlined in the capping Alternative 3N showed that the cap is expected to be stable and permanent, requiring only maintenance or repair following flood events. The expected losses from such events would be expected to be small, comparable or smaller than losses from removal of the contaminated sediment.

All alternatives except the no action alternative include the implementation of ICs to place restrictions on dredging and anchoring to protect the integrity of the armored cap, to limit potential disturbance and resuspension of buried sediment near the upland sand separation area where one location exists with TEQDF concentrations exceeding the sediment cleanup goal (for Alternatives 2N, 3N, 4N, 5N, and 5aN), or restrictions to prevent disturbance of the dredge residuals below the cover layers in the remediated areas (Alternative 6N).

Alternatives 1N, 2N, and 3N are containment alternatives that provide substantial long-term protectiveness while avoiding environmental impacts applicable to Alternatives 4N, 5N, 5aN and 6N, all of which require disruption of the existing armored cap to conduct stabilization or removal and disposal of impacted materials. However, Alternatives 1N, 2N, and 3N do not provide any treatment or removal of the dioxin/furan principle threat waste. Alternatives 4N, 5N, and 5aN all provide increased long term effectiveness compared to Alternatives 1N, 2N, and 3N because the most highly contaminated waste would either be stabilized or removed. Alternative 6N provides the greatest long-term protectiveness and effectiveness because the waste material, except for the dredge residuals below the cover layers, would be permanently removed from the San Jacinto River and there would be no potential for a future release from the site. With Alternative 6N, there would be no concerns regarding the long term viability and effectiveness of a maintenance program that would have to endure for an extremely long time (750 years by one estimate). Alternative 6N also the only alternative that provides for complete removal of the dioxins and furans principle threat waste.

Engineering analysis of the stability of a permanent cap (Alternative 3N) has determined that the cap may remain protective when subjected to the erosive forces under any of the flow scenarios (including a 500-year flood event) evaluated in the hydrodynamic modeling. In situ capping, as discussed in EPA and USACE guidance (EPA 2005; USACE 1998), is a demonstrated technology that has been selected by EPA for sediment remediation sites across the United States. However, the site's location within the San Jacinto River creates an uncertainty regarding the ability of an engineered cap to reliably contain the dioxin waste over the very long time that the dioxin will remain hazardous. By one estimate the dioxins and furans will remain hazardous for approximately 750 years. The uncertainty comes from the severe storms and floods that have occurred in the area, and the potential for barge strikes to compromise the cap. The potential for barge strikes is heighted because of the increased barge traffic after the completion of the temporary armored cap.

The uncertainty inherent in any quantitative analysis technique used to estimate the long-term reliability of the cap is very high. This includes the empirical analysis developed by Maynord (2000) to estimate the potential scour of the cap due to prop wash generated by ship traffic since a lot of the site data needed to properly perform this analysis were not available. The latter analysis probably has the smallest uncertainty associated with any of the evaluations performed to assess the long term reliability of the cap, and its estimated uncertainty is at least ± one order of magnitude. So, if the estimate of prop induced scour is 10 centimeters, then than range of uncertainty would be from 1 to 100 centimeters. This estimate of the uncertainty takes into account the lack of a complete data set for the site and the uncertainty in Maynord's empirically based methodology itself. Further, changes in channel planform morphology due to bank erosion, shoreline breaches, etc. during a high flow event caused by a major flood or hurricane as occurred in the San Jacinto River during the 1994 storm is beyond the ability of existing sediment transport models to simulate.

The impact of continued subsidence on the integrity and reliability of the existing cap to prevent any release of contaminated material would be dependent on the long-term rate of subsidence. The latter is not well known and cannot be predicted with any reliability. In general, subsidence and the slow rise in sea level would both result in slightly deeper water depths over the eastern cell and northwestern area of the cap, but it is not believed that these effects would be substantial enough to affect the tidal, river and wind induced circulation in the San Jacinto River estuary.

The Alternative 6N construction releases, which may be the most extensive of all the alternatives, are predicted to result in TCDD increases of 3 to 10 ng/kg over most of the site, with increases of over 30 ng/kg immediately adjacent to the waste pits. However, the use of BMPs as described above would reduce the impact of TCDD resuspension. For Alternative 1N, the no action alternative, the initial TCDD present over the site is approximately 8 ng/kg. Therefore, the total TCDD present following construction of Alternative 6N would be 18 ng/kg (8 ng/kg initial plus 10 ng/kg increase) over the site, but well below the cleanup goal of 200 ng/kg. The model-predicted decline of TCDD in surface sediment concentrations within the site corresponds to a half-life of 11 years. Although the model results vary year-to-year due to differences in flow conditions (which drive differences in sediment transport), the nature of the predicted recovery curve (i.e., an exponential decline) exhibits an asymptotic behavior, which is expected because concentrations of dioxins/furans would be expected to approach regional background concentrations associated with remaining sources of dioxins and furans (i.e., point and non-point sources, transport from upstream, etc.) in the area.

In summary, Alternative 6N has the greatest long-term effectiveness and protectiveness of all the northern area alternatives because all of the waste material would be removed and not subject to the potentially severe conditions in the San Jacinto River, and because any construction related releases would result in sediment concentrations initially well below the cleanup goal with further sediment concentration declines over the long term.

South of I-10

As noted in the previous section, soil with TEQ_{DF} concentrations exceeding the cleanup goal is isolated from the surface by clean overburden. The only route of potential exposure is through excavation into the impacted depth interval. Through the use of appropriate personal protective equipment and proper management of excavated soil, the potential risks posed by the impacted soil can be reliably and effectively managed. The physical markers (Alternative 3S) would draw attention to the ICs and enhance their effectiveness. Alternative 4S would achieve long-term effectiveness by permanently removing the impacted soil from the 0- to 10-foot depth interval from the site and securely disposing of the soil in a permitted landfill. While the ICs, particularly with the addition of physical markers (Alternative 3S), would provide reliable long-term protection, they rely on the integrity of future construction workers to comply with the restrictions. Therefore, complete removal of the impacted soil in the depth interval of potential excavation (Alternative 4S) will provide the highest level of long-term effectiveness because it is not subject to inappropriate future use of the area or any erosion/scour of the waste material that may result from a future extreme storm. Alternative 4S also the only alternative that provides for complete removal of the dioxins and furans principle threat waste from the Southern Impoundment.

2.10.3 *Reduction of Toxicity, Mobility, or Volume through Treatment*

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of the remedy.

North of I-10 and Aquatic Environment

Alternatives 1N and 2N do not include additional measures to reduce the toxicity, mobility or volume of material. However, a portion of the soils in the western cell were previously solidified during the TCRA. Thus, these alternatives are comparable in reduction of toxicity, mobility, or volume of material. Alternative 3N further reduces potential mobility within the TCRA site by increasing the protection of the armored slopes, and thus ranks more favorably than Alternatives 1N and 2N. Alternatives 4N and 5N take additional measures through S/S (Alternative 4N) or removal (Alternative 5N) of approximately 52,000 cy of sediments and soils, and are comparatively better than Alternative 3N for reduction of toxicity, mobility, or volume of material. Potential mobility of the highest concentration materials addressed in

Alternatives 4N and 5N would be increased during remedy implementation, somewhat offsetting any reduction in toxicity, mobility, or volume of material. Alternative 5aN removes approximately 137,600 cy of sediment, and thus compares more favorably for reduction of toxicity, mobility, or volume of material than Alternatives 4N and 5N, but subject again to possible issues related to mobility of materials during remedy implementation. Alternative 6N has the greatest volume of removal – 200,100 cy. This alternative is more effective in reducing the toxicity, mobility, and volume of waste compared all of the other alternatives.

South of I-10

Alternatives 2S and 3S do not include any treatment of impacted soil. Alternative 4S would include some treatment of excavated soil, as needed to eliminate free liquids for transportation and disposal. The treatment may involve amendment of the soil with Portland cement or similar product, which would reduce the potential mobility of COCs. Water removed from the excavation would be treated, if necessary, to reduce toxicity prior to discharge.

2.10.4 *Short-Term Effectiveness*

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved.

North of I-10 and Aquatic Environment

Alternatives 1N and 2N do not entail any construction, and thus have no short-term impacts. Alternative 3N has the shortest construction duration, two months, of the remaining alternatives. Alternatives 4N, 5N, 5aN, and 6N have estimated construction durations ranging from 13 to 19 months. Alternative 3N does not result in water column, sediment, or tissue impacts (except for minor turbidity during armor rock placement), and has the lowest risk to worker safety, the lowest greenhouse gas and particulate matter emissions, and the least traffic and ozone (smog) impact. Further, Alternative 3N does not disturb the armored cap or require handling of sediments. Compared to Alternatives 4N, 5N, 5aN, and 6N, which have longer durations, Alternative 3N ranks more favorably for short-term effectiveness.

Alternatives 4N, 5N, 5aN, and 6N each have risk of short-term impacts associated with residuals and releases during construction. Because of their longer duration these alternatives also have a higher likelihood that a high-water event during construction could overtop perimeter water quality control features, which would exacerbate short-term impacts because the armor cap needs to be removed to accomplish the work. Alternatives 4N, 5N, 5aN, and 6N have a predicted increases in water column TCDD concentrations over alternatives 1N, 2N, and 3N. However, the actual levels would be reduced to the maximum extent practicable by the use of BMPs during construction.

Alternative 4N has a longer construction duration than Alternatives 5N and 6N and all entail removing portions of the armored cap and managing a volume of sediments. Compared to Alternative 3N, there is higher risk to worker safety (8 to 9 times the number of injuries and fatalities, and higher environmental impacts (8 to 9 times the number of hours of operation and truck trips, due to releases that would be expected during construction. Alternative 4N is considered similar to Alternative 5N for emissions of ozone precursors, particulate matter (smog-forming) and greenhouse gases; under Alternative 4N, construction is limited to work within the site perimeter and does not result in additional emissions during off-site shipment of sediments, but this is counterbalanced by the shorter duration of Alternative 5N.

Alternative 5aN has the longest construction duration. Alternatives 5aN and 6N are the least favorable for short-term effectiveness. The greater number of work hours has attendant higher worker safety risk (20 times the number of injuries and fatalities compared to Alternative 3N, and higher emissions of ozone precursors, particulate matter (smog-forming) and greenhouse gases (20 times the number of equipment operating hours and truck trips compared to Alternative 3N, and the time required for Alternatives 5aN and 6N to achieve protection is also longer. Alternative 6N also has the most short-term environmental impact due to water column releases during dredging, and the expected localized increase in tissue concentrations from these releases, as well as generated dredge residuals, that may increase the overall surface weighted average concentration TEQ_{DF} immediately following dredging. However, the actual levels would be reduced by the use of BMPs during construction, including raised berms, sheet piles, dewatering and excavation in the dry, two layers of residuals cover, etc.

BMPs may be successful in mitigating potential resuspension and releases. During construction, however, BMPs could be overwhelmed during significant storm and flood events. For alternatives 4N, 5N, 5aN, and 6N, which require removal of the armored cap during construction, the consequences of flooding could be significant as the exposed and disturbed materials would be at risk of spreading beyond the remedial area. For the estimated construction durations of these alternatives, there is a 30 to 40 percent likelihood that such a flood could occur during construction. Therefore, these alternatives will include design and construction methodologies to mitigate and reduce the impact of storms during construction. These methodologies may include armor cap removal in sections, operational controls, etc.

South of I-10

Alternative 2S does not entail any construction, and thus has no short-term impacts. Excavations (Alternatives 3S and 4S) would require BMPs to control dust and storm water. Short-term impacts associated with Alternative 3S would be minimal given the shallow depth of excavation, limited volume of material that would be moved, and absence of significant concentrations of COCs in the shallow soil. Alternative 4S would require exposing soil with TEQ_{DF} concentrations exceeding the PRGs, which introduces the potential for exposure to COCs through direct contact with the soil, inhalation or ingestion of impacted dust, and contact with impacted soil suspended in runoff. The volume of soil and the duration of the project would also be greater than for Alternative 3S, and Alternative 4S would require off-site transportation of the soil to a disposal facility, increasing the potential for exposure to COCs, emissions of greenhouse gasses, nitrogen oxides, and particulate matter, and potential tracking of COCs off-site. However, measures developed in the Remedial Design will be implemented to reduce the amount of any materials lost during transportation.

2.10.5 *Implementability*

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

North of I-10 and Aquatic Environment

Alternatives 1N and 2N do not have any implementability issues because they do not entail construction. Both are more favorable from an implementability standpoint compared to Alternatives 3N, 4N, 5N, 5aN, and 6N. Alternative 3N is a short-duration project that entails proven technology (i.e., the same activities were demonstrated during construction of the armored cap) that can be deployed with readily-available materials and local, experienced contractors.

Implementability issues, such as TCRA site access, limited staging areas, restrictions on equipment size, and availability of off-site staging area properties are greater for Alternatives 4N, 5N, 5aN, and 6N compared to Alternative 3N because of the much larger scope and scale of these alternatives. Identifying and securing an off-site staging area is considered an even greater challenge for Alternatives 5N, 5aN, and 6N compared to Alternative 4N because dredged sediment may need to be managed at the off-site staging area, which requires a larger footprint, and given the nature of the dredged material, might make finding a willing landowner difficult. Proper management of cap material and excavated wastes, and on-site processing and management for dredged sediments for off-site transportation to neighboring roadways, will be critical for effective implementation of Alternatives 5N, 5aN, and 6N. Finding a suitable off-site facility for Alternatives 5N, 5aN, and 6N is considered a more significant implementability challenge than Alternative 4N because the former alternatives will manage dredged sediments at the facility. Compared to Alternative 5N, this issue is magnified for Alternatives 5aN and 6N because of the greater volume of material that must be handled at the off-site facility. Based on these factors, Alternative 3N is less favorable than Alternatives 1N and 2N, but more favorable than the remaining alternatives.

Alternative 4N requires the removal of the armored cap, and requires S/S to be completed for an area of sediments that is typically submerged and would need to be dewatered, which is considered a technical challenge. Engineering controls for Alternative 4N may not be adequate to prevent the release of sediments exceeding cleanup goals to the surrounding environment; this would be especially true during potential high flow events that could occur during construction. Alternative 4N is considered to be less favorable for implementability compared to Alternative 3N.

Alternatives 5N, 5aN, and 6N also require removal of the armored cap and management of sediment and soil for off-site disposal. Similar to Alternative 4N, engineering controls may not be adequate to prevent the release of sediments exceeding cleanup goals to the surrounding environment. For Alternatives 4N through 6N there is a 30 to 40 percent chance that a high water event could occur during construction resulting in overtopping of the engineering controls. Thus, all of these alternatives are considered equally less favorable as Alternative 4N for implementability compared to Alternatives 1N, 2N, and 3N. However, the impact of high water events will be mitigated by the use of BMPs during construction including raised berms, sheet piles, removal in sections, and operational controls including scheduling that will be developed during the Remedial Design.

South of I-10

There are no significant implementability concerns associated with Alternatives 2S and 3S. None of the alternatives requires specialized equipment, techniques, or personnel. Coordination with property owners would be required to establish ICs and for access to the project work site. Alternative 4S would involve more physical activity for implementation, including off-site transportation of impacted soil, but the operations are routine for remedial actions. The additional implementability concerns are the increased truck traffic on Market Street and the potential for flooding while impacted soil is exposed during implementation of Alternative 4S. Provisions may need to be made to handle the additional volume of traffic. The duration of the excavation should not exceed 7 months and implementation could be timed for periods when high water is least likely.

2.10.6 *Costs*

The estimated present worth costs for alternatives range from $9.5 million for Alternative 1N to $99.2 million for Alternative 6N and from $0.14 million for Alternative 1S to $9.93 million for Alternative 4S. Cost for each alternative are presented in the table below. Detailed cost estimates are provided in Appendix A.

Summary of Estimated Costs for Alternatives

Area Alternative Applies To	Alternative	Estimated Cost[1]
North of I-10 and Aquatic Environment	1N – Armored Cap, Operations, Monitoring, and Maintenance	$9.5M
	2N – Armored Cap, Institutional Controls, and Monitored Natural Recovery	$10.3M
	3N – Permanent Cap, Institutional Controls, and Monitored Natural Recovery	$12.5M
	4N – Partial Solidification/Stabilization, Permanent Cap, Institutional Controls, and Monitored Natural Recovery	$23.2M
	5N – Partial Removal, Permanent Cap, Institutional Controls, and Monitored Natural Recovery	$38.1M
	5aN – Partial Removal of Materials Exceeding Cleanup Goals, Permanent Cap, Institutional Controls, and Monitored Natural Recovery	$77.9M
	6N – Full Removal of Materials Exceeding Cleanup Goals, Institutional Controls, and Monitored Natural Recovery	$99.2M
South of I-10	1S – No Further Action	$0.14M

	2S – Institutional Controls	$0.27M
	3S – Enhanced Institutional Controls	$0.67M
	4S – Removal and Off-Site Disposal	$9.93M
Note: [1] Total costs for north of I-10 and aquatic environment include $9 million for the TCRA armored cap. M - million TCRA – time critical removal action		

2.10.7 *State/Support Agency Acceptance*

TCEQ has been informed about the Preferred Remedy for the site.

2.10.8 *Community Acceptance*

Community acceptance will be determined through the Public Comment process based on EPA's interpretation of comments received during the public comment period and the questions received at the public meeting.

2.11 PRINCIPAL THREAT WASTES

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP § 300.430(a)(1)(iii)(A)). In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile which generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. The "principal threat" concept is applied to the characterization of "source materials" at a Superfund site. At the site, the northern waste pits sediment contain calculated TEQ_{DF} over 43,000 ng/kg, and the Southern Impoundment soils contain calculated TEQ_{DF} over 50,000 ng/kg. The northern waste pits sediment maximum TEQ_{DF} is 215 times higher than the noncancer hazard based cleanup goal and the Southern Impoundment maximum TEQ_{DF} is 208 times higher than the noncancer hazard based cleanup goal. The baseline noncancer HI for a recreational visitor exposure to sediments at the site is 60, which is more than an order of magnitude greater that the acceptable HI of 1. Dioxin and furans are highly persistence chemicals and will not breakdown for hundreds of years. There is considerable uncertainty regarding biodegradation of dioxins and furans, however by one estimate, the dioxin and furans will remain at the site above the cleanup goals for approximately 750 years (Khoury 2016).

The site is located in the San Jacinto River, which has experienced a number of severe storms and floods in the past. For example, the 1994 flood exceeded the 100-year return period storm, resulted in severe riverbed scour while cutting of new channels outside of the river bed, destroyed or damaged thousands of homes, and undermined and ruptured pipelines both inside and outside of the river channel. The 1994 storm crested at 27.09 feet at the Sheldon, Texas gauge located about five miles upstream of the site. Previous storm resulted in even higher crests of 31.5 feet 1940 and 32.90 feet in 1929.

Because of the elevated concentrations of dioxin and furans, which are over two orders of magnitude higher than the acceptable concentration, and the highly toxic and persistence nature, there is a significant risk to human health or the environment should exposure occur. With the regular occurrence of severe storms and flooding in the area, there is uncertainty that the waste material can be reliably contained over the long term and therefore should be considered highly mobile. Because the dioxin and furan waste in the northern impoundments and southern impoundment at the San Jacinto River Waste Pits Site is both highly toxic and highly mobile, it is considered a principle threat waste.

2.12 PREFERRED REMEDY

Based on consideration of the requirements of CERCLA, and the detailed analysis of remedial alternatives, EPA's preferred alternatives are 6N and 4S. This section provides EPA's rationale for the Preferred Remedy, implementation of both alternatives 6N and 4S, and its expected outcomes.

2.12.1 *Summary of the Rationale for the Preferred Remedy*

The Preferred Remedy is protective of human health and the environment, complies with ARARs, and provides the best balance of tradeoffs among the balancing criteria. It reduces risks within a reasonable time frame, provides for long-term reliability of the remedy, and minimizes reliance on institutional controls. It will achieve substantial risk reduction by removing the most contaminated materials, reduces remaining risks in the aquatic environment to the extent practicable through MNR, and manages the remaining risks to human health through ICs.

EPA considered several options for contaminated materials. EPA's preferred remedy includes full removal of contaminated materials above cleanup levels for the following reasons:

- The material is highly toxic and under baseline conditions highly mobile and therefore is considered a principal threat waste.

- The location of materials, either partially submerged within the San Jacinto River (northern impoundments) or on a small peninsula on the San Jacinto River (southern impoundment), result in limited ability to treat the waste in place without the threat of a release during the remedial action.

- The area has a high threat of repeated storm surges and flooding from hurricanes and tropical storms, which if the material was left in place, could result in a release of hazardous substances.

For all of these factors, the Preferred Remedy provides greater permanence in comparison to other alternatives. Less costly alternatives rely on remedies that have a higher chance of failure by leaving principal threat waste source materials in the river, resulting in greater uncertainty as to their long-term effectiveness.

2.12.2 *Description of the Preferred Remedy*

The Preferred Remedy is a final action for the San Jacinto River Waste Pits Site. It addresses site related unacceptable human health risks associated with consumption of fish and direct contact (skin contact and incidental ingestion) with sediment and soil. It also addresses site related ecological risks to bottom-dwelling organisms (benthic invertebrates), birds, and mammals.

The Preferred Remedy includes excavation and off-site disposal of principal threat waste source materials (i.e., mobile and highly-toxic sediment and soil) from impoundments in and adjacent to the San Jacinto River. ICs will be used to prevent disturbance of the remediated areas (e.g., dredging, anchoring, construction, and excavation) and alert future property owners of subsurface materials exceeding cleanup goals. MNR will be used to ensure remedy protectiveness in the aquatic environment.

North of I-10 and Aquatic Environment

For the full removal alternative, the recreational visitor exposure scenario was considered for area north of I-10. The cleanup goal for protection of the recreational visitor is a TEQ_{DF} concentration of 200 ng/kg. Figures 22 and 23 present the area to be remediated.

The work area would be isolated with berms, sheet piles, and/or with turbidity barrier/silt curtains. As with the partial removal alternatives, cap rock, geomembrane and geotextile from the existing armored cap, which currently isolates and contains impacted material, would need to be removed prior to beginning excavation. Similarly, upland excavation could require dewatering to allow excavation of impacted sediment in relatively dry conditions, and excavation of submerged sediment would require isolation of the work area with a turbidity barrier/silt curtain and sheet piles. Excavated sediment would be further dewatered and stabilized at the offloading location, as necessary, to eliminate free liquids for transportation and disposal. Some operations, such as water treatment, could be barge mounted. Following removal of impacted sediment, the area from which sediments are removed would be covered with two residuals management layers of clean sediment to reduce intermixing.

This alternative entails removal of approximately 200,100 cy of sediment from the TCRA footprint and the area near the upland sand separation area, which would require a relatively large offloading and sediment processing facility to efficiently accomplish the work, which would require barge unloading, sediment re-handling, dewatering, stockpiling, transloading, and shipping to the off-site landfill facility. Additional activities would include management and disposal of dewatering effluent, including treatment if necessary.

South of I-10

This remedial alternative involves excavation and replacement of soil in the three remedial action areas (Figure 24). Soil would be removed within these areas to a depth of 10 feet below grade. Implementation of this remedial alternative would require dewatering (groundwater lowering) to allow excavation of impacted soil in relatively dry conditions and may need to be timed to try to avoid high water and periods when storms are most likely. Excavated soil would be further dewatered, as necessary, and potentially treated to eliminate free liquids prior to transporting it for disposal. Effluent from excavation and subsequent dewatering would need to be handled appropriately, potentially including treatment prior to disposal. Excavated soil would be disposed of at an existing permitted landfill, the excavation would be backfilled with imported soil, and vegetation would be re-established.

An existing building (an elevated frame structure) and a concrete slab would need to be demolished and removed prior to excavating the underlying soil. These features would be replaced, if necessary.

The removal volume (50,000 cy) was calculated assuming a conservative excavation side slope of 2 horizontal to 1 vertical. Transportation and disposal costs were estimated assuming that all of the excavated material would be transported to a licensed landfill for disposal. During remedial design, potential cost savings associated with segregating clean soil and using it as backfill may be explored.

2.12.3 *Summary of the Estimated Remedy Costs*

The information in the cost estimate summary tables presented below are based on the best available information regarding the anticipated cope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This is an order-of-magnitude engineering cost estimate that is expected to be within plus 50 to minus 30 percent of the actual project cost.

Engineer's Estimate for Alternative 6N

Item	Description	Quantity	Unit	Unit Price	Total
DIRECT CONSTRUCTION COSTS					
0001	Mobilization/Demobilization	$ 56,962,000	%	8%	$ 4,560,000.00
0002	Environmental Protection and Erosion Control	1	LS	$300,000	$ 300,000.00
0003	Construction Payment and As-Built Surveys	1	LS	$300,000	$ 300,000.00
0004	Construction Materials Testing	2	EA	$15,000	$ 30,000.00
0005	Silt Curtain	1	LS	$100,000	$ 100,000.00
0006	Additional Armor Rock Placement	0	TON	$107	$ -
0007	Remove Armored Cap - Land Based	6,200	CY	$72	$ 443,000.00
0008	Remove Armored Cap - Water Based	23,700	CY	$92	$ 2,180,000.00
0009	Wash Water Armored Cap - Treat and Dispose	2,702	TON	$530	$ 1,432,000.00
0010	Dispose Armored Cap - Debris Landfill	54,000	TON	$48	$ 2,576,000.00
0011	Water-based Excavation/Dredging	200,100	CY	$46	$ 9,205,000.00
0012	Land-based Excavation	0	CY	$12	$ -
0013	Sediment Residuals Cover	19,800	CY	$30	$ 594,000.00
0014	Sediment Stabilization prior to Shipment	200,100	CY	$30	$ 5,911,000.00
0016	Haul & Disposal of Sediment to Class 1 Landfill	308,100	TON	$110	$ 33,891,000.00
0017	Replace Geotextile	0	SY	$6.25	$ -
0018	Replace Armor Rock A/B	0	TON	$78	$ -
0019	Replace Armor Rock C/D	0	TON	$107	$ -
DIRECT CONSTRUCTION TOTAL:					**$ 61,522,000.00**
IN-DIRECT CONSTRUCTION COSTS					
0020	Engineering Design	$ 61,522,000	%	6%	$ 3,691,320.00
0021	Construction Administration/Observation	$ 61,522,000	%	6%	$ 3,691,320.00
0022	EPA 5 Year Review (Net Present Value)	1	LS	$108,000	$ 108,000.00
0023	Institutional Controls (Net Present Value)	1	LS	$70,000	$ 70,000.00
0024	Long Term MNR Monitoring (Net Present Value)	1	LS	$264,000	$ 264,000.00
0025	Long Term Cap Monitoring (Net Present Value)	0	LS	$88,000	$ -
0026	Cap Maintenance (Net Present Value)	0	LS	$181,000	$ -
IN-DIRECT CONSTRUCTION TOTAL:					$ 7,824,640.00
PROJECT TOTAL					$ 69,346,640.00
PROJECT ROUNDED TOTAL:					**$ 69,400,000.00**
30% Contingency					**$ 20,820,000.00**
TCRA Design and Construction Cost					**$ 9,000,000.00**
TOTAL ESTIMATED COST FOR 6N					**$ 99,220,000.00**

Engineer's Estimate for Alternative 4S

Item	Description	Quantity	Unit	Unit Price	Total
DIRECT CONSTRUCTION COSTS					
0001	Mobilization/Demobilization	1	LS	$250,000	$ 250,000.00
0002	Environmental Protection and Erosion Control	1	LS	$5,000	$ 5,000.00
0003	Construction Surveys, Site Preparation & Utility Clearance	1	LS	$20,000	$ 20,000.00
0004	Bollards	0	EA	$741.26	$ -
0005	Land-based Soil Excavation	50,000	CY	$12.00	$ 600,000.00
0006	Marker Layer	0	SY	$0.67	$ -
0007	Replace Excavated Soil	0	CY	$3.50	$ -
0008	Vegetative Cover	3	AC	$4,000.00	$ 14,000.00
0009	Wellpoint Dewatering and Treatment	1	LS	$400,000.00	$ 400,000.00
0010	Stabilization of Soil Prior to Shipment	25,000	CY	$30.0	$ 750,000.00
0011	Off-site Haul and Disposal of Sediment (Class 2)	75,384	TON	$55.0	$ 4,146,000.00
0012	Backfill	50,000	CY	$11.25	$ 563,000.00
0013	Demo 6" Thick Concrete Pad	9,710	SF	$7.57	$ 74,000.00
0014	Demo House	800	SF	$7.89	$ 6,000.00
0015	Replace House	800	SF	$125.00	$ 100,000.00
0016	Replace 6" Thick Concrete Pad	9,710	SF	$5.38	$ 52,000.00
DIRECT CONSTRUCTION TOTAL:					$ 6,980,000.00
INDIRECT CONSTRUCTION COSTS					
0017	Engineering Design	1	LS	$200,000	$ 200,000.00
0018	Construction Administration/Observation	$ 6,980,000	%	5%	$ 349,000.00
0019	EPA 5 Year Review (Net Present Value)	1	LS	$108,000	$ 108,000.00
0020	Soil Management Plan and Notices	0	LS	$100,000	$ -
IN-DIRECT CONSTRUCTION TOTAL:					$ 657,000.00
PROJECT TOTAL					$ 7,637,000.00
PROJECT ROUNDED TOTAL:					**$ 7,640,000.00**
TOTAL ESTIMATED COST FOR 4S (with 30 percent contingency)					**$ 9,932,000.00**

2.12.4 *Expected Outcomes of Preferred Remedy*

The intent of the Preferred Remedy is to be protective of human health and the environment and to attain ARARs. It is consistent with current and reasonably anticipated future uses of the land and river. It is also intended to minimize reliance on ICs to the extent practicable. The Preferred Remedy will reduce sediment and soil contamination and remove principal threat waste from the site in order to achieve long-term protectiveness.

2.13 STATUTORY DETERMINATIONS

Under CERCLA section 121, 42 U.S. Code §9621, the EPA must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as their principal element. The following sections discuss how the Preferred Remedy meets these statutory requirements.

2.13.1 *Protection of Human Health and Environment*

The Preferred Remedy will protect human health and the environment by removing contaminated materials from the site, capping residual material left post-dredging activities, using MNR to further reduce concentrations in less contaminated areas, and placing ICs as necessary. Specifically the exposure of recreational fishers and recreational visitors to dioxins and furans will be reduced through removal of the contaminated materials to risk based cleanup levels. Exposure of future construction workers to dioxins and furans in contaminated soil will not occur because soil above the risk based cleanup level will be removed from the site to a depth of 10 feet below grade. Ecological receptors (benthic invertebrates, birds, and mammals) will be protected because there will no longer be an exposure pathway to contaminated materials.

2.13.2 *Compliance with Applicable or Relevant and Appropriate Requirements*

The NCP §§ 300.430(f)(5)(ii)(B) and (C) require that a Record of Decision describe the Federal and State ARARs that the Selected Remedy will attain or provide justification for any waivers. The implementation of the Preferred Remedy generally will not require Federal, State, or local permits because of the permit equivalency of the CERCLA remedy-selection process (40 CFR 300.400(e)(i)), but remedial actions will be completed in conformance with substantive technical requirements of applicable regulations.

The ARARs can be broken out into three different categories, although some ARARs may belong to more than one of these categories:

- Chemical-specific requirements
- Location-specific requirements
- Performance, design, or other action-specific requirements.

Chemical Specific

Chemical-specific ARARs are typically the environmental laws or standards that result in establishment of health- or risk-based numerical values. Chemical specific ARARs include Clean Water Act (CWA) criteria and State water quality and waste standards.

Section 303 and 304 of the Clean Water Act and Texas Surface Water Quality Standards - Section 303 of the CWA requires states to promulgate standards for the protection of water quality based on Federal water quality criteria. Federal water quality criteria are established pursuant to Section 304. Texas Surface Water Quality Standards are relevant to the evaluation of short-term and long-term effectiveness of the remedial alternatives.

Section 401 Water Quality Certification of the Clean Water Act as Administered by Texas - Section 401 requires that the applicant for Federal permits obtain certification from the appropriate State agency that the action to be permitted will comply with State water quality standards. Although environmental permits are not required for on-site CERCLA response actions, the preferred remedy will incorporate elements to comply with State water quality standards. Consultation with the TCEQ may be necessary to confirm that the final design of the Selected Remedy meets the substantive requirements of Section 401 of the CWA.

Section 404 and 404 (b)(1) of the Clean Water Act - Section 404 requires that discharges of fill to waters of the United States serve the public interest. In selecting a remedial alternative including discharge of fill, EPA would be required to make the determination that the placement of materials into the San Jacinto River serves the public interest as necessary to remediate source material from within the EPA's Preliminary Site Perimeter. The area within the EPA's Preliminary Site Perimeter includes wetlands in the area north of I-10, and a plan will need to be established that addresses the requirements (to the extent practicable) of Section 404 and 404(b)(1).

Location Specific

Location-specific ARARs include restrictions placed on concentrations of hazardous substances or the implementation of certain types of activities based on the location of a site. Some examples of specific locations include floodplains, wetlands, historic places, land use zones, and sensitive habitats. Location-specific ARARs include the Rivers and Harbors Act, Coastal Zone Management Act, and Federal Emergency Management Agency/National Flood Insurance Program regulations.

Rivers and Harbor Act and Texas State Code Obstructions to Navigation - The site is within a navigable waterway, and the State of Texas regulates the obstruction of navigable waters within the State involving the construction of structures, facilities, and bridges or removal and placement of trees that would obstruct navigation (Riddell 2004). The State of Texas considers land within the bed and banks of rivers to be public and requires access for the public to such areas. With the exception of the TCRA Site, which is required to be restricted to minimize the potential for disturbance of the armored cap by vehicular traffic or vandalism, the remedial alternatives will not limit public access. Documentation of compliance with this ARAR would entail documenting, with State concurrence, the extent to which a remedial alternative would affect navigability of the San Jacinto River in the vicinity of the site.

Coastal Zone Management Act and Texas Coastal Management Plan - Federal agency activities that have reasonably foreseeable effects on any land or water use or natural resource of the coastal zone (also referred to as coastal uses or resources and coastal effects) must be consistent to the maximum extent practicable with the enforceable policies of a coastal State's Federally approved coastal management program (National Oceanic and Atmospheric Administration 2010). The Texas General Land Office administers the Texas Coastal Management Consistency certification process.

Action Specific

The action-specific ARARs are generally technology or activity-based limitations or guidelines for management of pollutants, contaminants, or hazardous wastes. These ARARs are triggered by the type of remedial activity selected to achieve the RAO and these requirements may indicate how the potential alternative must be achieved. Action-specific ARARs include CWA water quality certifications (Section 401) and discharges of dredged and fill material (Section 404), Clean Air Act, Endangered Species Act, and other wildlife protection acts.

Texas Pollutant Discharge Elimination System - Within the State of Texas, the National Pollutant Discharge Elimination System, which demonstrates compliance with Section 402 of the CWA, is administered by TCEQ and referred to as Texas Pollutant Discharge Elimination System. A Storm Water Pollution Prevention Plan in accordance with the general permit requirements of TXR150000 (permit for construction activities) will need to be prepared.

Noise Control Act - Noise abatement may be required if actions are identified as a public nuisance. Due to the TCRA Site being bounded by water on three sides and adjacent to a highway overpass on the fourth side and the industrial activities in the area south of the I-10, noise from the construction activity is unlikely to constitute a public nuisance. If necessary, BMPs would be implemented to reduce the noise levels. If materials are delivered to or removed from the project area by truck, noise greater than 60 decibels in close proximity to sensitive receptors (schools, residential areas, hospitals, and nursing homes) will be avoided. Truck routes will be selected to avoid sensitive receptors to the extent possible.

Hazardous Materials Transportation and Waste Management - The Preferred Remedy includes removal and transportation of sediments to an off-site disposal facility. Off-site disposal would also be required for limited quantities of waste, such as used personal protective equipment and any debris or vegetated materials required to be removed during clearing and grading activities, associated with all of the remedial alternatives except for no further action. The contractor will be required to package any hazardous materials in appropriate containers and label containers in accordance with TxDOT requirements. The development of remedial alternatives anticipates that all disposal will be at a permitted landfill facility. If an off-site facility needs to be established for dewatering sediment or transloading waste from barges to trucks or rail cars, it may require a solid waste permit.

2.13.3 *Cost Effectiveness*

The Preferred Remedy is cost-effective and represents a reasonable value for the costs incurred. In making this determination, the following definition was used: “A remedy shall be cost-effective if its costs are proportional to its overall effectiveness” (40 CFR 300.430(f)(1)(ii)(D)). EPA evaluated the “overall effectiveness” of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and ARAR-compliant) by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of this remedial alternative was determined to be proportional to its costs and hence this alternative represents a reasonable value for the money to be spent.

The total estimated net present value cost to implement the Preferred Remedy is $109 million. Less costly alternatives rely leaving principal threat wastes on-site in a river prone to flooding and hurricanes, therefore have greater uncertainty as to their long-term effectiveness.

2.13.4 *Utilization of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Practicable*

EPA has determined that the Preferred Remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the site. Of those alternatives that are protective of human health and the environment and comply with ARARs, EPA has determined that the Preferred Remedy provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against off-site treatment and disposal and considering State and community acceptance.

2.13.5 *Preference for Treatment as a Principal Element*

The Preferred Remedy satisfies the statutory preference for treatment as a principal element of the remedy. The NCP establishes the expectation that treatment will be used to address the principal threats posed by a site whenever practicable, (40 CFR 300.430[a] [1] [iii] [A]). In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be contained in a reliable manner, or will present a significant risk to human health or the environment should exposure occur. Excavated materials (both from the river and peninsula) will be stabilized prior to off-site disposal.

2.13.6 *Five-Year Review Requirements*

Because the Preferred Remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

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TABLES

FIGURES

Appendix A: Remedial Alternative Cost Development